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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CIV.—No. 2698.] *LONDON: FRIDAY, SEPTEMBER 14, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE 8d. BY INLAND POST 10d.

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See Full Page Advt., page 56, Aug. 24.

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See Advertisement page 63, Aug. 31. 2402

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See half-page Advertisement page 85, Sept. 7.

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PATENTS AND DESIGNS ACT, 1907.

Notice is Hereby Given, that

EDWARD WILKINSON ASHBY, of 4, Dunbar Street, Sunderland, County Durham, seeks leave to amend the Specification left in connection with the application for Letters Patent No. 107565, for "Improvements in the Construction of Hollow Metal Derricks." Particulars of the proposed Amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 5th September, 1917.

Any person or persons may give notice of opposition to the Amendment by leaving Patents Form No 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal. H 773

W. TEMPLE FRANKS, Comptroller-General.

South-Western Polytechnic

INSTITUTE, CHELSEA, S.W. 3.

UNIVERSITY and TECHNICAL DAY and EVENING COURSES in MECHANICAL and ELECTRICAL ENGINEERING commence 24th September, 1917.

Scholarship Examination, 17th September, Ten a.m.

Apprenticeship Scheme for Engineers.

Prospectus on application to the SECRETARY (Room 34).

Telephone: 599 Western. H 451

ENGINEERING AND TECHNICAL OPTICS.

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UNIVERSITY OF LONDON.

Goldsmiths' College,

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Enrolment commences 17th SEPTEMBER.

Special terms to those enrolling before 22nd SEPTEMBER.

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NEW SESSION
BEGINS MONDAY, SEPTEMBER 24TH.

Details of the Classes may be had upon application at the Office of the Institute, or by letter to the PRINCIPAL. H 749

City and Guilds Technical COLLEGE, FINSBURY.

(LEONARD STREET, LONDON, E.C. 2).

CIVIL AND MECHANICAL ENGINEERING.
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ELECTRICAL ENGINEERING,
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The University of Sheffield.

SESSION 1917-1918.

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The TECHNICAL LABORATORY COURSES commence 24th September, 1917. H 114

W. M. GIBBONS, Registrar.

LONDON COUNTY COUNCIL.

Hackney Institute,

DALSTON LANE, N.E.

(Close to Hackney Downs Junction (G.E.R.), and Hackney Station (N.L.R.)).

SESSION COMMENCES 17th SEPTEMBER, 1917.

EVENING LECTURES and LABORATORY COURSES are held in Mechanical Engineering, Motor Engineering and Electrical Engineering subjects.

For prospectus and full information apply to the Institute.

JAMES BIRD, H 685
Clerk of the London County Council.

The Polytechnic, Regent St., W.

SCHOOL OF ENGINEERING.

HEAD OF DEPARTMENT: HENRY J. SPOONER, M.I.Mech.E., A.M.Inst.C.E., M.Inst.A.E., F.G.S.

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Forms of Tender, Conditions of Contract, and all particulars may be obtained on application to The CONTROLLER OF SUPPLIES, H.M. Office of Works, &c., King Charles Street, Westminster, London, S.W.1.

The Commissioners do not bind themselves to accept the lowest or any Tender.

Tenders must be delivered before Eleven a.m. on Thursday, the 20th September, 1917, addressed to The Secretary, H.M. Office of Works, &c., Storey's Gate, London, S.W.1, and endorsed "Tender for Packings and Jointings."

H.M. Office of Works, &c.,
12th September, 1917. H 794

THE GREAT INDIAN PENINSULAR RAILWAY COMPANY.

The Directors are prepared to receive

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the following STORES, namely:—

GRINDSTONES.
MISCELLANEOUS ARTICLES.
ANTIMONY.
SPARK ARRESTERS.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Grindstones," or as the case may be, not later than Eleven o'clock a.m., on Thursday, the 20th September, 1917.

The Directors do not bind themselves to accept the lowest or any Tender.

By order, H. WALPOLE, Secretary.

Company's Offices,
48, Copthall Avenue, E.C.,
London, 7th September, 1917. H 776

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase in

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Before any Tender is accepted the proposed Purchaser will be required to make a statutory declaration that he is a British subject and that he is not buying for or on behalf of a foreigner or foreign corporation or corporation under foreign control.

A Report on the past operations and the present position of the Company has been prepared for the Public Trustee by Messrs. Litton, Pownall, Blakey and Higson, Chartered Accountants, and this Report can be inspected either at their Offices, No. 42, Spring Gardens, Manchester, or at the Offices of the Public Trustee, Ringway, London, W.C.

Conditions of Sale and Forms of Tender may be obtained at the offices of Messrs. Litton, Pownall, Blakey & Higson, or at the offices of the Public Trustee, and all Tenders will be subject to such conditions.

All Tenders must be delivered in sealed envelopes to the Public Trustee on or before Twelve o'clock noon on the 1st day of October, 1917, and must be marked "Tenders. Schaffer and Budenberg Co.'s Shares," and the successful tenderer will be advised of the acceptance of his tender within one week thereafter.

The Purchaser will be entitled to all profits shown by the Balance Sheet of the Company dated the 31st day of December, 1916, and to all profits of the Company subsequently earned. H 766

APPOINTMENTS OPEN.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.

POST OF ORGANISING SECRETARY.

The Representative Council of the Association of Engineering and Shipbuilding Draughtsmen invite

Applications for the Post of GENERAL SECRETARY.

The salary attached to the post is £250 per annum rising by increments of £25 to a probable maximum of £400.

The successful candidate must be prepared to give his entire services to the Office and to reside in Glasgow until 1st March, 1918, when headquarters will be removed to London.

Six months' notice in writing to terminate the agreement on either side.

Applications should state age, qualifications and organising ability, and six copies should be forwarded not later than 21st September, to the SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 94, Hope Street, Glasgow. Envelopes to be marked "G.S." H 661

Important Association of

Agricultural Engineers REQUIRES the whole time SERVICES of a SECRETARY to act with Executive Council in developing the usefulness of the Association to its Members for post-war trade. Competent knowledge of commercial conditions in Foreign and Colonial markets is necessary, together with ability to place before the Members up-to-date information on all important trade and legislative matters affecting their interests.—Please reply to H 709, Offices of ENGINEERING, stating age, present position, experience, &c.

COUNTY BOROUGH OF HUDDERSFIELD TECHNICAL COLLEGE.

Principal: J. P. HUDSON, M.A., B.Sc.

Chief Assistant Lecturer in

Mechanical Engineering REQUIRED, at once. Appointment for duration of the war in first instance, with prospect of permanency. Salary £300. Further particulars on application to the Secretary.

T. THORP, Secretary. H 746

BOROUGH POLYTECHNIC INSTITUTE.
BOROUGH ROAD, S.E. 1.

The Governors require at an early date the

Services of an Additional

LECTURER and DEMONSTRATOR in the ENGINEERING DEPARTMENT. Preference will be given to candidates who have had teaching and workshop experience.

Salary commencing £300 per annum, according to qualifications. Candidates should be ineligible for military service.

Particulars of the appointment and forms of application may be obtained from the Principal,

C. T. MILLIS. H 772

Teacher.—Wanted, a Whole-

TIME TEACHER OF ENGINEERING SUBJECTS at the L.C.C. Hackney Institute, Dalston Lane, London, E. 8. The appointment is for the duration of the war and is open only to men who are ineligible for Military Service. Full particulars may be obtained from the Principal of the Institute. Salary £200 a year. Apply to the EDUCATION OFFICER (T. I.) Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary). A form T. 1/17 giving particulars will then be sent. Form must be returned by 11 a.m. on 19th September, 1917, accompanied by copies of three testimonials of recent date. Canvassing disqualifies. H 715

WANTED.
PRACTICAL FOUNDRY MANAGER.

The Stanton Ironworks

COMPANY, LTD., near Nottingham, REQUIRE in the immediate future a Practical Foundry Manager to act for the present as Assistant to the Foundry General Manager with a view of assuming control of that Department, which employs about two thousand men, as soon as practicable. A knowledge of Pipe Foundry not essential.—Applications, giving full particulars of past experience, should be addressed to the FOUNDRY GENERAL MANAGER. H 701

Manager Wanted, for the

Midlands. Thoroughly competent to undertake control of the manufacture of Milling Cutters, Reamers, Hobs, Gear Cutters, &c., of all descriptions, from the blank to the finished tool. Must be experienced in handling both male and female labour, able to fix rates, and capable of introducing the most up-to-date methods of production.—Write, stating full details of experience, also age and salary expected, to U. G. C., care of SWEET's, 30, Cornhill, E.C. 3. H 579

First-class Accountant

WANTED, exempt from military service. One with experience of engineering costing preferred. Good salary to a competent man.—Write, BOX, H. S. 142, care of JACKSON'S, 19, Cullum Street, E.C. 3. H 689

Wanted, Confidential Clerk

for Manager's Office, large engineering firm in Manchester district. Good stenographer, accustomed to engineering terms. Up-to-date office arrangements, &c. No person already on Government work will be engaged. State age, full details of experience and salary required.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 3606. H 553

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Wanted at Once, Good All-

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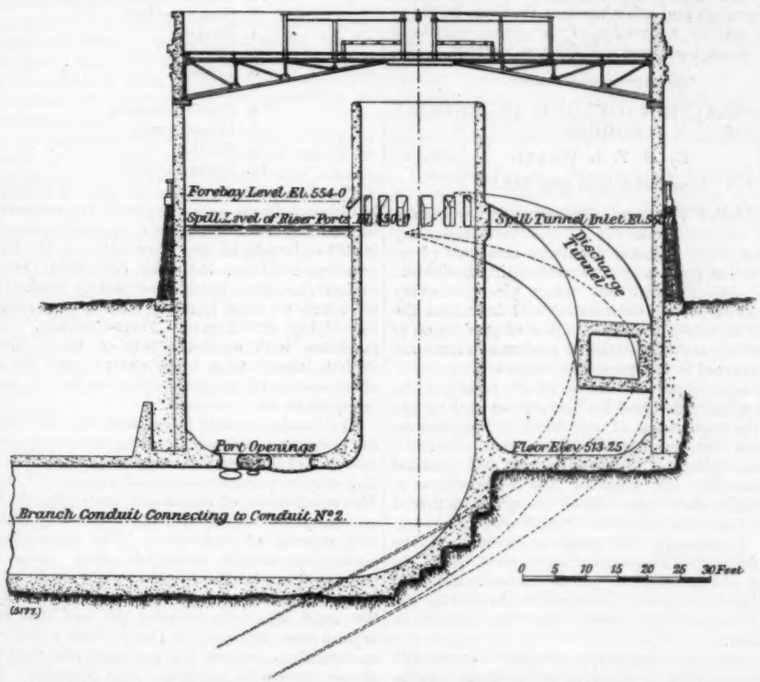
SURGE TANKS.

WHEN hydro-electric plant on a large scale was first made available, interruptions in the service were so frequent that adequate regulation of long pipe lines was regarded as of small importance or impossible of achievement. With experience, however, power transmission grew more trustworthy and interruptions became more infrequent, but more irritating, compelling increased attention to be paid to the lesser evils arising from want of satisfactory regulation. A storage pond or artificial lake constructed at the end of an aqueduct had been the usual means by which hydraulic engineers had sought to remove those troublesome effects of sudden fluctuations in flow, recognised under the name of "water hammer" or "surging," according to the character of the pressure waves. Such a form of open storage having an unrestricted flow is not without its objections. Many of these reservoirs need and are provided with overflows to carry off excess of water following a "shut down." The waste of water under such circumstances was little regarded, or treated as a necessary consequence; to-day, however, it would probably be admitted that no form of mechanism for controlling the supply of water to turbines and waterwheels was well designed that disregarded the loss of valuable water. Deflecting nozzles and governor-operated by-pass valves entail other objections besides waste of water, and dissatisfaction arising from the use of such appliances has led to the introduction of improvements in the storage reservoir.

The object of any form of mechanical device must be, on the one hand, to prevent undue rise of pressure on diminution of draught, and, on the other, to furnish water quickly on demand without waiting for the velocity of the long feeder to pick up. Those requirements are met to a considerable extent by a reservoir or tank placed at the down-stream end of a closed aqueduct, and the simplest form such a reservoir could take would be the turned-up end of the conduit carried to a height somewhat above that of high water in the forebay or storage pond. The variation of water-level surface in such a tank on fluctuations of load would resemble wave-like swells or "surges," hence the term "surge tank." To follow the action a little more in detail we may consider the actual operation in a typical case. The surge tank is supposed to be situated as near as possible to the power-house. The penstocks are led out from a point on the main feeder near the stand-pipe, and in order to keep the pressures in the main conduit as small as possible are so arranged that the greater part of the total drop occurs between the end of the main conduit and the power-house.

When the load is constant the water-level in the tank or stand-pipe will remain stationary, indicating the hydraulic gradient for original steady flow, but, assuming that the conduit is of fair length, any sudden demand for more water can only be supplied from the stand-pipe, because the velocity of the water in the conduit cannot change with sufficient rapidity. The lessened pressure, on being transmitted back to the pond, will, after some time, depending on the length of the conduit, produce an accelerating head, which in its turn increases the velocity of the water in the main feeder. The water-level in the stand-pipe continues to drop and the velocity of the current to increase, until such increased velocity becomes equal to the new demand for power. Meanwhile the stand-pipe level will have fallen below the elevation of the existing velocity gradient, so that a greater acceleration than necessary has been created in the conduit pipe, forcing the water in the stand-pipe to a higher level and finally retarding the conduit velocity. A pendulum motion is therefore set up tending to raise the level in the stand-pipe as much above its normal position as the water fell below it on the original demand. Neglecting the efforts of the turbine governor, these oscillations will go on repeating themselves for some time, gradually diminishing in amplitude under the influence of friction.


Forebay Level El. 554·0
Spill Level of Riser Ports El. 550·0
Spill Tunnel Inlet El. 52
Discharge Tunnel
Port Openings
Floor Elev. 513·25
Branch Conduit Connecting to Conduit N° 2.
0 5 10 15 20 25 30 Feet

SURGE TANK OF THE ONTARIO POWER COMPANY'S PLANT AT NIAGARA FALLS.

The cycle movement embracing the entire flow points to the observance of two important conditions in the construction of the tank or stand-pipe. Evidently the greater the quantity of water in the stand-pipe—that is, the larger the area—the smaller will be the fluctuations in level and the less will be the variation in head at the water wheels. But in order to keep this surging within a limited amplitude, the diameter of the tank may require to be increased to such an extent as to make the cost prohibitive. The second point is the height to which it will be necessary to carry the stand-pipe in order to prevent waste of water over the top, with possibly the provision of a spillway. For though, as we have seen, the fluctuations will die out under friction and amount of gate opening, it is necessary to take into account the possibility of synchronising load changes. The probability that the load will oscillate many times synchronously with the natural period of the water wave in the stand-pipe may be slight, but it cannot be overlooked, for practically the loads may be of any size, and can cause serious surging without being absolutely synchronous. There is no doubt that many simple tanks have been built and are now operating, with a large amount of risk, not necessarily because the dangers are unknown, but because the provision of adequate protection would be too expensive.

The dimensions of the surge tank are therefore of prime importance, for if the volume of water operating falls below a certain critical amount, regulation becomes impossible. Moreover, with the increasing length of conduits and the larger consumption of water these tanks become necessarily very large and expensive. The introduction of some improvement becomes pressingly urgent. Consequently the differential surge tank has been devised to meet both the demand for economy in construction and increased efficiency of regulation. We believe we are correct in attributing this improvement to Mr. Raymond D. Johnson, of Albany, N.Y., though it is not impossible but that others may have made earlier use of a similar principle in particular installations. Certainly Mr. Johnson has been the first to recognise the importance of the innovation, to develop its theory with some completeness, and to recommend its general adoption.

The term "differential" is used to designate that form of surge tank in which the water in the tank is made to fulfil independently the two functions of storage and of pressure. The main feature of the device consists of a stand-pipe of somewhat less diameter than the conduit, and a storage tank of larger dimensions surrounding the stand-pipe and communicating with it only by means of fixed parts, or holes, in the smaller pipe, as shown in the annexed illustration. There is no necessity for the stand-pipe to be in the midst of the large tank, though this may be the form evolution would naturally follow. It may be, if more convenient, situated on one side, and communicate with the tank by a restricted by-pass. Such an arrangement would resemble that of a dash-pot, but in either case, if successfully designed, will fulfil the purpose of effectually damping the vibrations, that by superimposing one on another tend to attain dangerous proportions in an ordinary tank of possibly twice the area. By this considerable diminution of size the first requirement of reduced cost is met.

The principle of operation is easily understood and the mechanism is simple, though to secure satisfactory results in practice great care is necessary in design. But it is precisely in those cases in which the load changes are irregular and difficult to handle that the advantages of this extra care are most apparent. Where the load is steady and the main pipe feeder short, the differential form has little superiority over the simple surge tank. In that form the water-level in the tank is both the accelerating level which urges the water to flow faster or slower and equally that of the stored water. The variation of velocity in the conduit depends upon the level changes in the tank, and the rapidity of such velocity change is proportional to the amount of the level change. Therefore the capacity has to be much greater than it would be if the accelerating head could instantly be applied to the pipe without having to wait for the water-level to be drawn upon. In the differential form a resistance is interposed between the tank and conduit, and consequently the level of the stored water is quite independent of the acceleration, and does not affect the water-wheel governor directly. The water in the stand-pipe acts like a simple tank of small dimensions supplemented by the steadying action of the stored water. Mr. Johnson describes the effect of drawing the water from the tank through constricted openings as producing a forced loss of head, "causing a sudden change in the accelerating level to a value which holds constant during the period of velocity change, and until the level in the tank becomes coincident with the level represented by the accelerating head, which coincidence obtains simultaneously with the acquirement of the new velocity value as demanded."

The most notable application of the principle is

to be found in the Ontario Power Company's plant at Niagara Falls, and is briefly described by Mr. Mitchell in the monograph * to which reference has been recently made in these columns. In that case the surge tank terminates an 18-ft. concrete conduit, and the illustration on page 269 will make the method of application evident. The water during surges is carried up in the conduit riser or stand-pipe and allowed to overflow through ports, or over the top of the riser if the surge is of sufficient magnitude, into the body of the enclosing surge tank. The stored water as demanded is drawn into the conduit only through the small ports into the tank, which connect with the conduit. Surplus water and overflow water are discharged to the river by means of a tunnel, whose upper length, in the form of a helix, conforms to the circular tank wall, the spillway crest of the tunnel mouth being on a level with the riser port discharge level, and 4 ft. below head-water level at the intake forebay. Mr. Mitchell reports that the regulating action in practice has been excellent, not only in this case, but at Eugenia Falls, where surge tanks have been installed on the 4-ft. penstocks leading to the power-house, the tanks being placed on their respective pipes near the upper level of a 542-ft. head.

This testimonial is on some grounds more satisfactory than the results derived by Mr. Johnson from elaborate mathematical analysis, because it is based on results that sum up the effect of many variables of which rigorous mathematics can take only imperfect cognisance. Among these variables must be included friction, the changes in load that may be anticipated with the corresponding increment in velocity, and other factors, as the length of the closed penstock between the regulator and the power-house. Nevertheless the examples worked out by a method of arithmetical integration or summation of results at short intervals are distinctly instructive, especially as affording comparisons between the simple and differential surge tank. Mr. Johnson's conclusions have not been materially altered by independent, and possibly hostile, critical examination. In the particular case submitted as an example the increment in velocity due to the opening of the wheel gates and change in hydraulic gradient is assumed to amount to 2 ft. per second, and it is found necessary, in order to keep the variation of head within necessary and defined limits, to construct a simple tank, supposing that to be the form of regulation adopted, having an area of 910 sq. ft. carried to a height of 70.5 ft. On the other hand, if the differential form is employed, having a riser 7 ft. in diameter, carried to a height of 75.9 ft., the area of the tank need be only 410 sq. ft. Mr. Johnson points out that when circumstances make it difficult to carry the regulation structure as high as calculation indicates, it is feasible, and even desirable, to reduce the height by the use of compressed air. This can be done by closing the reservoir at the top and connecting it with a compressed air chamber. Since the compressor plant would merely have to make up for leakage and the absorption of air by the water, there need be no difficulty in construction. Such an arrangement, however, interferes with the extreme simplicity of the method and should, we submit, be avoided where possible. For it may be questioned whether the stand-pipe should be built high enough to hold all the water when approximately full load is rejected by the wheels, but should be allowed to overflow or escape through relief valves when the water reaches a given height. The waste of water would be so reduced in quantity as to be negligible. Without these considerations the cost of production would be reduced some 50 per cent., and, of greater importance, the regulation would be more satisfactory, because there is an increased damping effect upon the surge waves after their inception and the chance of trouble from piling up of successive waves is reduced.

The determination of the size of the ports and their arrangement is of the utmost importance, for the whole differential principle depends for its success on the choking action these produce. The demanded load rather than the rejected load will be the decisive factor in determining the size, and as there is not much danger of getting them too large it is always better to err on that side. The amount or rate of change of load, the determining factor in the area of the ports, is of course a matter of judgment, to be decided by the plant and the varying requirements of market. The variation in increment is likely to be proportionately greater in small than in large plants. It is generally of advantage to have the ports at different levels in the riser, if their distribution can be such as not to interfere with the differential action and occasions no impact with convergent streams. In any case they are quite simple in construction and unalterable in size. If the area could be made to vary automatically with the load change, the scheme would be ideal, but the introduction of a mechanical device to alter the size has not been found practicable, and such mechanism would interfere with the simplicity of design. Besides the performance of the tank is dependent on net effective head, governor action—purposely not considered here—changes in water wheel efficiency at different heads, gate openings and other matters that can be determined only by knowledge of the actual conditions under which the plant will have to operate.

* "Canadian Hydraulic Power Development." By Charles H. Mitchell, C.E. Dominion Water Power Branch, Canada; Ottawa. 1916.

THE TRAINING OF OUR INDUSTRIAL FORCES.

By H. F. L. ORCUTT.

(*Concluded from page* 242.)

The Skilled Workman.—The education and training of the rank and file of our industrial army calls for great changes, for large measures of reconstruction politically, and unremitting individual effort. Development has taken place in every department of our commercial and industrial life to such an extent that possibilities of production of the luxuries and necessaries of modern existence are demonstrated to be practically unlimited.

The most important factor of all, however, the fitting of the individual for his task, so that he can make the highest use of well-developed appliances, has been left to chance. Worse than that, the deliberate policy of restricted output and curtailed apprenticeship are some of the by-products of present-day conditions. In all the great industrial nations there has been but little progress economically. Technically, our progress borders on the marvellous. In science, in mechanical outfit, in systems and methods, we can be content. Effective use of these elements, however, is retarded by the lack of trained man-power from the highest to the lowest.

Full enjoyment of industrial progress is impossible as it is restricted by economic absurdities. Paths of reform run in two parallel lines: first that which can only be done by the community, or political; second, that which must be mainly undertaken by the individual. The political work of the corporation or company involves new duties of citizenship, which have already been mentioned.

It remains to consider what should be the technical training of the rank and file of our great industrial army. We can practically ignore the meagre present-day efforts as relics of bygone times and patches on our educational system in which we have retained the forms and discarded the virtues of our ancestors.

Present-day apprenticeship training, technical school instruction, junior technical schools, continuation schools and the like do not harmonise with our developments in mechanical operations and modern methods of manufacturing. They are so much out of gear that, before laying down courses of training, it will be necessary to clearly define those occupations in which we must have special proficiency essential to modern engineering organisation. We must bear in mind that we have under review particularly those industries in which are employed automatic machinery, operated under thoroughly organised management.

The key industry of all mechanical equipment is the machine tool trade. In the so-called "machine tool" we have the mechanical instrument on which we chiefly depend for the production of automatic machines necessary to cheapen production of special articles, as well as the tools, fixtures, gauges and appliances used in the manufacture of these articles.

A classification of the necessary skilled mechanics includes the machine tool man, the maker of special machines, the jig and fixture gauge and special tool man. To these must be added the mechanical specialist, or one who is particularly skilled in operating and maintaining in an efficient state special machinery as used in factories producing large quantities of a single article on fully, or partly, automatic machines, these machines being usually attended by unskilled or semi-skilled operators.

Certain industries, like shipbuilding, general engineering shops, locomotive and railway shops, are also, of course, dependent on the trained man. The principal "trades" where a special and definite apprenticeship is necessary are given below. They do not include clerical occupations, many of which call for engineering training. They are given with due consideration to the latest mechanical inventions and methods.

1. General machinists.
2. Tool-makers.
3. Gauge-makers.
4. Fitters.
5. Grinders.
6. Turners.
7. Planers.
8. Pattern-makers.
9. Foundrymen.
10. Smiths.
11. Boiler-makers.

The development of the accurate machine tool in different forms does away with the necessity for the old-fashioned seven years' apprenticeship which is still so largely in use. For instance, the modern grinding machine, both for cylindrical and flat surfaces, assists to produce accurately finished work for which we were formerly entirely dependent on the highly skilful man. Thread-milling, capstan machines with elaborate sets of tools, displace skilled labour to a large extent, and do away altogether with apprenticeship as far as certain occupations are concerned.

The development of these particular machines at the same time creates the necessity for an entirely new class of skill and knowledge, which the individual can only acquire by a special course of training. The subdivision of operations and refinements of certain machines, again, make it necessary to devise new courses of instruction. The apprenticeship course, as usually arranged, often leaves men untrained in the things they ought to know and trains them in the things they do not need to know. We must also duly consider the fact that as we depend more and more on the machine attended by an unskilled operator the accuracy and durability of our automatic machines must increase. High-speed steel makes further calls on the stability and endurance of such machines. All of which means that the engineering expert of to-day must have a knowledge of refinement and accurate workmanship not so widely called for in the past.

General Machinist.—The trade of general machinist is the most important of all the specialised callings in engineering. New conditions and future developments compel us to especially consider this trade in respect to its general character, by whom it should be learned and the course of experience and education necessary to proficiency.

The primary object of this trade should be to acquire general knowledge and all-round practical training in mechanical operations rather than special skill. The training must include working experience in the principal mechanical operations of turning, grinding, milling, planing, erecting, fitting, scraping, operating automatics and gear cutters, and foundry and drawing-office experience.

The full course of uninterrupted apprenticeship must be served by those who wish to become efficient general managers, works managers, designers, leading draughtsmen, cost clerks or efficient engineers, foremen, supervisors of automatic plants, grinding experts and those who wish to control research and scientific study.

The term of service must be four years. The time devoted to the different classes of work must be proportioned in accordance with shop conditions in which the pupil serves his time. The working

experience in these departments will naturally vary with the aptitude of the apprentice. It should be the subject of control on the part of the employer who, in his own interest, should take the trouble necessary to produce an all-round efficient man. It should be emphasised that this particular course of apprenticeship is indispensable to success in so-called repetition work—that is, in the management of specialised plants arranged for the production of articles of good quality at low costs and in large numbers.

We must depend principally on our large engineering concerns to undertake this class of apprenticeship training. The wide variety of manual experience can only be practically acquired in large shops equipped with plant constantly engaged in production and operated on a sound commercial basis. It is to be hoped that employers controlling such establishments will recognise their obligations to the community and combine their facilities with public educational institutions in such a manner that we may meet the constantly increasing demand for mechanical experts of this class.

Tool-maker.—The specialised manufacturing plant is dependent directly on the tool-maker for its maintenance and efficient operation. No other skilled workman is more important to our success as producers of articles made in quantities on automatic machines.

For our supply of tool-makers to-day we depend too much on the casual man, when we should be turning out the systematically educated individual. The period of training cannot be less than four years. It must include manual experience in turning, universal and plain grinding, fitting, universal milling, planing and shaping and special tuition in gauge-making. The training must also embrace drawing-office experience, and, of course, a special course in the tool-room itself. Individuals must be selected with special care. A probational period must be the subject of careful attention to make sure that the requisite mental capacity and the "touch" of the highly skilled craftsman are not wanting.

Good records in school work, although not indispensable, should be specially considered in accepting applicants who wish to learn this trade. In large manufacturing plants where it is possible the pupil can also with advantage spend some time as unskilled operator of automatic machines, acquiring training in using the special appliances which he will be called upon to make as tradesman.

Gauge-maker.—This expert is also as indispensable to the modern manufacturing shop. His training must be on similar lines to the tool-maker, but with a larger proportion of time devoted directly to the trade itself. Educational or school records are not as important as with the tool-maker, but individual fitness is highly essential. A knowledge of turning, universal and plain grinding is necessary; shaping and universal milling must be understood. For some branches of gauge-making especially long experience will be necessary before proficiency is acquired. It is significant that Great Britain does not possess any gauge-making establishments which can be compared with the world-famous concerns found in other countries. Both the "trade" and the "industry" are in a state of neglect and of low standard. Four years is the minimum training time which should be given to this highly interesting art.

Fitter.—The training of this calling must necessarily vary with the requirements of different industries. In nearly all cases, however, the terms of apprenticeship, as in force at present, must be revised. We have particularly to reckon with two features of the modern shop as compared with the older establishments. First, the new system of manufacturing (whether in small or large quantities), by which definite and scientific limits of accuracy are fixed independently of the fitter's judgment and are maintained by inspection. Second, the development of machine processes, by which these limits are easily attained by unskilled operators. In other words, the two qualities on which we have been accustomed to rely principally from the fitter, *i.e.*, uniformity and accuracy, can be now partially transferred to the semi-skilled or unskilled machine attendant. This principle is so far generally recognised that it is already a well-accepted indication of cost reduction to state how far improved methods reduce the amount of fitter's work.

Under new methods the terms of apprenticeship for becoming a proficient fitter need not exceed four years, and in many cases can be three years. A portion of this time should be spent on the common machine operations of turning, grinding and milling-machine attendance, and on a short working or school training in practical drawing, with probably some scraping and filing instruction.

Grinding.—Although grinding is a very old occupation (even ancient), broadly speaking, it is not a trade to which has been assigned definite courses of apprenticeship. It is so new as a mechanical operation that it is almost futile to lay out a course of training in the art itself without first briefly explaining its significance as a most important process of reducing costs and improving quality. Its future possibilities must be explained as well as its past achievements.

In the near future it is certain to be classed as a standard "trade," the mastery of which calls for a greater amount of skill and technical knowledge than almost any other special mechanical occupation. Every day records are made by which the abrasive wheels take over operations done by other cutting tools. They include flat and surface grinding, internal and external cylindrical grinding, formed grinding, universal and tool grinding, and improved economies in the oldest of all, fettling or snagging.

It ranges from the lightest to the heaviest parts. It combines speed of output with an accuracy unknown in any other trade—parts 2 in. in diameter from which 0.025 stock is removed, ground to a limit of 0.001, finishing 4,000 pieces per day.

To mention the other extreme, machines are now working finishing rolls weighing 32 tons, 50 in. diameter, and 21 ft. long. On this machine up to 4¼ cub. in. of stock is removed in one minute, using wheels of 8 in. face. Innumerable instances can be given of speed of output combined with accuracy which make one wonder at the prevalent contentment with other methods found in the usual engineering establishment.

The economics of grinding are in principle the same as in other trades. They involve a study of:—

1. Its adoption for certain operations on account of suitability, accuracy or speed of output.
2. Its cutting tools (the wheel).
3. Its use in relation to, or co-ordination with, other machine processes.
4. Its use in the hands of skilled, semi-skilled or unskilled operators. Proficiency in 1, 2, and 3 and as a skilled operator call for definite apprenticeship training.

There is no single trade connected with mechanical engineering which can be compared with "grinding." It offers almost unlimited possibilities to the ambitious worker who may adopt it as a special calling. Opportunities for serving as apprentices are limited, more limited in Great Britain than in any other industrial country. The term of complete service can hardly be less than four and a half years to five years. The purely grinding experience must be preceded by at least three years' training in general machinist's work.

Although the efficiency of the grinding machine is demonstrated beyond a question, it is used by engineers to only a fractional extent of its possibilities, consequently opportunities for manual training are limited. In England there is no concern organised and equipped for the production of a complete line of abrasive wheels. Ideal facilities for the study of this important detail are only found abroad. In arranging a detailed course of apprenticeship in grinding, particular attention must be given to the combined use of the lathe and the cylindrical grinder. Experience has proved that the best results are usually attained in shops where the turning and grinding are under the same departmental head.

Turner.—Departmental experience is necessary as a part of apprenticeship, with grinding and capstan machine work, fitting and erecting. Experience in actual grinding work is necessary. The modern fast grinding machine for plain cylindrical work now replaces much of the finishing formerly done on lathes. It is gradually taking over this work, and will continue to do so, both for work in large quantities and for single pieces, effecting reductions in cost and improving the quality and accuracy of finish. The economic production of cylindrical parts, whether soft or hard, of cast-iron, bronze or steel, is dependent on the grinding machine as well as the lathe. The apprenticeship training of the "turner" must include instruction in methods by which work is properly apportioned between the two processes.

Capstan or turret lathes are also rapidly taking over work formerly done by the skilled turner, replacing boring and chucking, facing, turning and thread cutting. As soon as quantities are required, or repetition production is possible, these machines, both of the vertical and horizontal type, large and small, become important means of reducing costs. Many engineering concerns will have to readjust their methods by transferring work from the skilled turner to the semi-skilled or unskilled capstan operator. No "turner" can now be termed fully trained who has not been instructed by actual experience on turret machine work, especially in consideration of the large amount of work now performed on the capstan and the grinding machines for which we were formerly dependent on the turner; the old seven years' term apprenticeship is unnecessary, three years are sufficient.

For those who choose the trade of heavy turning, experience in grinding will also be necessary. Although the art of finish-grinding heavy parts is not nearly so extensively developed as for light work, enough has been accomplished to prove that it will replace much lathe work, quality for quality, and competing in cost of production.

As in other special trades, short terms of experience in fitting and erecting machinery are desirable for the turner. Although this diversion may not directly assist to develop the skill of the individual, it will broaden the outlook of those who may be especially capable or ambitious to perfect themselves or use their trade as a stepping-stone to other positions. Besides, if we hope or expect to secure more intelligent tradesmen, for which there is a continual cry amongst employers, we must take the trouble to pay the cost of making them. Running fits, driving fits, clearances, oil spaces, face bearings, good fitting, interchangeability, &c., are unintelligible terms to those who have never brought parts together in the finished machine.

Planer.—The qualification of the individual who wishes to reach high efficiency in this trade should be especially considered. He should possess peculiar aptitude for ingenuity, understanding of accuracy, and the capacity for taking pains in the preparatory operations of fixing work. These qualities, combined with good knowledge of feeds and speeds, should produce results to satisfy the most ambitious worker or exacting employer. Generally speaking, this trade has not the standing it deserves. It is worthy of special effort on the part of the employer in training specialists and of the best talent which the tradesman can supply. The course of tuition should be three years, a portion of this time to be devoted to scraping as well as fitting.

Pattern-making.—This trade is much influenced by modern engineering. Pattern-making now calls for capabilities beyond those of a skilful manual worker at the bench. Recent progress in foundry practice is largely due to special developments in the art of pattern-making. The trade is becoming a branch of engineering calling for scientific and technical knowledge which the ordinary craftsman cannot be expected to master. He can only attain proficiency in a special branch of his calling.

Although apparently not fully recognised, it is time pattern-making should hold rank as an engineering profession. Until this profession is defined, apprenticeship training will not be properly organised. The professional or engineering course of training must include a term of apprenticeship as pattern-maker, followed by studies in certain departments of metallurgy; then machine-shop and foundry practice sufficient to enable the student to realise the working connection, necessary to cheap production, which must be maintained between the pattern-maker, the foundryman and the machinist.

The tradesman's course must include working pattern-shop experience and a certain time in the foundry and drawing office. Broadly, the trade may be specialised in :—

1. The ordinary wooden pattern work.
2. The moulding-machine pattern.
3. The die-casting pattern-making.

Three years should be served in (1), and one year extra in either (2) or (3). Candidates for this trade should have had general educational training above the ordinary.

Material savings in the costs of production can be made nationally if engineers will take the trouble to study results already accomplished by the ingenuity of the pattern-maker. Machining operations have been discarded wholesale, aided by the combination of accurate patterns and scientific foundry practice.

Foundrymen.—The innovations of the moulding machines will not have much effect on the course of training necessary to produce the good moulder or foundry journeyman. The transfer of work to the moulding machine at once reduces such work to an unskilled occupation in the same manner that the character of labour is altered by the transfer of an operation from the planer to the milling machine, or from the lathe to the turret machine. The skill and knowledge of the moulder is not much assisted by machinery, although his exertions may be relieved by mechanical devices, and his results made more accurate by scientific control. The term of service should be three years, supplemented by some experience in the pattern shop. It is high time that we began to consider the rough and strenuous occupations of foundrymen and boiler-makers worthy of qualifications other than accidents of birth and brute strength.

Foundry practice is already the subject of engineering and scientific study, but the efficiency of the tradesman is not what it would be if he were trained to better understand how his manual labour can be supplemented by engineering devices and scientific knowledge. His training should start with a better general education. It is taken for granted that all apprenticeship work must be accompanied by school instruction. Foundry apprenticeship should be no exception. It should include certain metallurgical tuition, and a course in the pattern shop, as well as instruction in those labour-saving appliances directly connected with the trade. The relations between progress and ignorance are the same in all departments.

Smiths.—As in other trades, that of smiths must be reviewed, giving consideration to altered and improved mechanical methods. These include :—

1. The use of rapid roughing-out machines, either turning or milling, by which parts cut off from bars replace forged parts.

2. As quantities increase the adoption of die stampings produced by drop hammers or other power forging machines.

The period of apprenticeship need not exceed three years, to include workshop experience in production on lathes and milling machines, and possibly as attendants to automatic machines. All dependent, of course, on the nature of the product of the works in which time is served.

Boiler-makers.—Although boiler-making is not directly a part of all engineering enterprise it deserves special attention as an engineering trade. Much the same general remarks can be applied as to the foundryman. The trade is highly important to this country, with its vast marine and naval responsibilities. Instruction in the trade should be systematically carried out, and particular attention given to recent developments in mechanical labour-saving aids.

How to Begin.—The trades enumerated are those fundamentally important to engineering progress. They all should, and can, be the subject of concentrated and systematic treatment by our educational authorities, our commercial and industrial leaders.

Legislative and political action and social reform are necessary. Important and effective work, however, can be immediately undertaken, unhindered by the deadening drag of Governmental supervision. This work can be most effectively and easily undertaken by our large engineering concerns. A beginning can quickly be made if not attempted on too large a scale. It is suggested that, without any difficulty whatever, at least half a dozen large concerns can be selected who will at once agree on a programme of uniform action. The following are put forth as the essentials on which agreement is desirable.

Arrange definite schedules of apprenticeship courses, embracing the essential trades. Agree on the starting age (16 years). Determine the rate of wages covering the term of serving—these rates to be at least a living wage. In the course of apprenticeship include school work for the pupil, to be considered as working time and paid for as shop work. This school work to be carried out on the firm's premises during working hours, under instructors supplied by the firm. In each case the firm to arrange the course of work and instruction under an apprentice supervisor, whose sole duties are to guide the schooling and to whose direct control all apprentices must submit. Details of course must vary in accordance with the special business of the different concerns.

There are the strongest reasons for as little delay as possible in making a start. First and foremost is the fact that, as before stated, there is danger in the present position. This war has taught us nothing if it has not shown us that one of our greatest weaknesses, industrially, is the lack of skilled men in all departments in production and in the development of engineering enterprises. Just how and why is not universally understood, but it surely cannot be denied that there is but one method of "making good," and that is to train men or our post-war efficiency will be doubtful. The lines of action suggested can be independently undertaken without extensive propaganda work or seeking aid from educationalists or politicians. They are thoroughly in accord with plans for the future which are practically accepted necessities of educational and industrial reforms.

We should at once create training camps for a new type of manager and engineer, who now have small chances of acquiring necessary manual experience under well organised conditions. Working experience should be acquired with the least possible delay, from which wider and more highly perfected methods can be developed for the future. It should not be difficult to make a beginning if effort is, as suggested above, at first confined to the co-operative work of a comparatively small number of concerns, who surely can be found with common ideals regarding the practical necessities of the times.

LITERATURE.

On Growth and Form. By D'ARCY WENTWORTH THOMPSON, F.R.S. Cambridge University Press. [Price 21*s.* net.]

To many whose life-work is of necessity devoted to "directing the sources of power in Nature to the use and convenience of man," the researches and the conclusions of the biologist awake but a languid interest; intelligent curiosity, when excited, has to be satisfied with the statements of authority. The broad issues of evolution, of heredity and similar problems are not matters of indifference to the engineer, but, with attention centred in his own work, he may be inclined to believe that the questions which long perplexed the philosopher have been settled with the decision and logical certainty of a proposition in Euclid, and that further investigation can only furnish fresh evidence for laws that are recognised and established. To such a one who reposes serenely on the Darwinian theory of natural selection, who is satisfied with the explanation that evolution follows the incorporation into the race of those mutations that operate beneficially to the preservation of the organism, and who bestows little attention on the causes and mechanism that promote these mutations, this book will come as a disturbing influence, questioning as it does the adequacy, or the need, of some approved formulas. It shows how imperfectly we have penetrated the true origin of causation, and the extent to which we have neglected sources of information that would have assisted in unravelling many weighty problems. The grounds for this neglect are not far to seek: we have been dazzled on the one hand by the glamour attaching to the theory of beneficent purpose and design, displayed in the adaptation of organism to environment, and misled on the other by failing to recognise the powerful co-operation of ever-present physical forces. It is the object of the author to show that the mechanism of physics as well as teleology has to be weighed and studied as a factor influencing the complex problem that involves the relation of growth and form, and of function and form, in the varied manifestations of life. Professor Thompson indicates very plainly that so long as we are willing to accept such phrases as "fortuitous variation" and "survival of the fittest" as affording satisfactory and final hypotheses, making us unwilling to look beyond to other processes in known and constant operation, so long will true progress be arrested and so long shall we be lulled in a deceptive ignorance.

We cannot escape from the conclusion that vital organisms are subject to the same physical forces that are at work in the inorganic world; the endowment of matter with the specific characteristics of vitality, such as the power of assimilation, or that of progressive cell-differentiation, only complicates the problem and makes the resolution of the observed resultant into its component forces more perplexing and uncertain. But some of the purely physical effects may be sifted out of the total observed phenomena, and indeed must be, if we would learn the extent that irregular, spontaneous mutations can enter into the result as an effective factor in the biological puzzle. The author, attacking the morphological side, has very properly insisted upon the importance of tracing the effect of mechanical and chemical forces in the growth and form of bioplasm, and inasmuch as these forces will always act similarly under similar conditions, it is possible to introduce the methods employed in mathematical deduction and analysis. "How far," says Professor Thompson, "mathematics will suffice to describe, and physics to explain, the fabric of the body, no man can foresee. It may be that all the laws of energy, and all the properties of matter, and all the chemistry of all the colloids are as powerless to explain the body as they are impotent to comprehend the soul. For my part, I think it is not so. Of how it is that the soul informs the body, physical science teaches me nothing . . . but of the construction and growth and working of the body, as of all that is of the earth, earthy, physical science is, in my humble opinion, our only teacher and guide." While insisting on the recognition of the presence of forces whose action will at least never be transgressed by any bodily mechanism, Professor Thompson does not deny the possible operation of processes that defy the known methods of physical investigation. He urges, however, that the want of any clear distinction between what is vital and what is purely physical, the absence of any definite separation of the two classes of phenomena, more than justifies the rigorous application of the laws of physical forces to the complex whole.

The employment of mathematical reasoning and symbols to explain the mechanical problem of form and extension in living organisms is not new, but the uncompromising advocacy of the need of adhering strictly to the principles of physical science before invoking some arbitrary device to tide over unexpected difficulties is as novel as we believe it will be welcome. The complete result, proceeding on a plan admirably conceived and adequately developed, is of profound interest. The author's intimate knowledge of the subject has enabled him to enrich with cogent illustration an argument that is presented with lucidity and literary distinction. Favoured, too, by this wide acquaintance with modern literature, the author has summarised and discussed much valuable information scattered through foreign serials and treatises and made it available to a wider circle. For this is essentially a "popular" treatise, meaning by that much-abused word that the book can be read with keen enjoyment by those who have not specialised in such subjects. No pains are spared to make clear what might be obscure, or to explain the more recent and consequently less familiar results of scientific research. The care taken now and again to avoid the mysteries of a differential coefficient is almost pathetic. And not

only are modern researches put under contribution: the problem of life in its many phases has occupied philosophers in all ages, and Professor Thompson seems to take as much delight in recalling the aphorisms of Aristotle and Lucretius, in displaying the penetration of Galileo and Swammerdam, as in discussing the utterances of the latest school of German thought.

In these columns it is not necessary to follow the details by which the author defines and establishes his position. Naturally he seeks the simplest forms of living matter to illustrate the operation of those physical agencies—surface tension, osmosis, adsorption—whose results it is his object to investigate. Much of his earlier chapters is therefore devoted to the consideration of the structure of the cell and the behaviour of the earlier forms of life, as the workings of mechanical energy check or control development along determinate and recognisable paths. We do not precisely understand the attitude assumed towards the controversy which centres round the vexed question of the relation to, or the identity of, the cell as it is prepared for examination under the microscope with the living cell performing specific functions in the complete and growing organism. Some authorities have cast doubts on the essential deductions derived from histological investigation of nuclear structure, urging that the appearances vary according to the manipulation practised and the reagents employed. Professor Thompson seems inclined to steer a middle course in these troubled waters, admitting the proved existence of certain formations known as nuclei, vacuoles, centrosomes, &c., but also recognising that some alleged structures are artificial, making the adoption of a satisfactory dividing line between the proved and speculative difficult to maintain. Such caution may be taken as an example of the fairness of the author in the presence of rival theories, a candour that is manifest throughout the book. The interest attaching to his description of the visible changes in a typical cell is by no means diminished by this cautious attitude, and the remarkable analogies suggested by a comparison between the results of diffusion experiments and the phenomena of karyokinesis lose nothing of their instructive force. A special education seems to be necessary to perceive in the mechanism of the chromosomes a satisfactory solution of the problem of heredity, as claimed on some hands. It must, however, be remembered that the author is dealing only with the morphological importance of these minute bodies.

The physicist finds himself on safer ground in presence of the phenomena of surface tension. He comprehends the forces that tend to reduce a surface to a minimum when a liquid body is subject to no other than its own molecular forces, and is prepared to admit the possibility of more complicated forms being exhibited under less simple conditions. A very pretty use is made of the principle of adsorption—primarily a capillary surface-tension phenomenon—from which an adequate explanation is forthcoming of some deviations from regular geometrical form. The general heterogenity of substances in cells induces a quantitative difference of surface that assists or restrains certain constituent molecules in their motion to the surface, giving rise to localised accumulations or concentration of particular salts, within narrow limits. Instances are given of deformities of structure in solitary and in tissue cells arising from the effects of weakened surface tension, and in certain sponges the same cause, coupled with osmotic pressure, will explain the tendency to deposit certain substances in lines of intercellular contact and close conjunction. Such instances are more than illustrations: they furnish grounds for confidently affirming that the form of the cellular framework in both animals and vegetables depends upon forces of molecular physics. Such reasoning does not exclude the possibility of the entrance of other agencies, that from their nature cannot be submitted to mathematical analysis, acting on and influencing ultimate form and growth. But while admitting the existence of such unknown factors, we have no evidence warranting the belief that at any stage the conformation of the material fabric escapes from the control of the physical forces which occasion the phenomena of surface tension and establish the laws of equilibrium and the principles of minimal areas.

To many the interest will increase as the author applies the mathematical modes of investigation to spiral conformation as exemplified in the horns of ruminants and the spirals of molluscan shells. It is a subject that Sir T. Cook attacked not unsuccessfully in his "Curves of Life," to which attention was drawn in these columns. The thought is enlarged here, and directed more closely to a particular end, the author not permitting himself any excursions into the alluring by-paths that invite a mind less severely trained in scientific method. There have not been wanting those who have attributed spiral growth to gravitational force, overlooking the obvious fact that though such a constant force would tend to bend the form into the direction of the vertical, it could never induce a spiral curve. Professor Thompson very neatly describes the spirally-formed shell or horn as a vector diagram of its own growth, displaying at all stages the direction of growth, radial and tangential, and the unchanging ratio of velocities in these directions. Accepting such a description, the result is seen to be due to the accretion of successive increments, each "similar in form, similarly situated, and of constant relative magnitude to each other," presenting precisely the features that characterise the development of the logarithmic spiral. The fearless application of mathematical principles to these forms brings the author sometimes into conflict with the older school of naturalists and of teleology, as elsewhere he will find other opponents. However, the suggestion here made that the resulting figure is the consequence of the growth of a generating curve at the lip of an orifice should be favourably received. The varying ratio in the rate of growth of the outer as compared with the inner border of the structure will explain the final form assumed. The growth, which admits of endless variation of figure, has strictly limited degrees of freedom—a vector motion at right angles to the axes of the shell and a sliding motion along that axis.

Through the many instructive problems connected with the growth of antlers, of teeth and beak and claw in the animal world, and the arrangement of leaves or phyllotaxis in the vegetable, the interest goes on increasing, but to make the argument intelligible considerable space would be needed. Similarly the problem of the shape of the bird's egg and of other hollow structures lends itself to the treatment that is uniformly pursued throughout. By applying physical laws to morphological development the author has invoked a subtle and powerful assistant, apparently capable of unravelling many mysteries, and one certainly that cannot be neglected. The concepts of heredity cannot influence its conclusions and the picturesque theories of evolution cannot disturb its logical deductions. Difficulties of interpretation beset the resolute inquirer by whatever path he travels, and it is easy to raise objections. The engineer might be disposed to dissent from the view that sees in the backbone of a horse the main girder of a double-armed cantilever bridge, or that would explain the skeleton of any animal as the mean resultant of the stresses to which as a mechanical system it is exposed; but the broad survey such views suggest is likely to bring the problem of evolution into more progressive grooves. For our part we are content to accept the book as a welcome expression of the tenets of a school of philosophic biology that is daily growing in authority and numbers.

General Chemistry. By HAMILTON P. CADY, Ph.D., Professor of Chemistry in the University of Kansas. New York and London: Hill Publishing Company. [Price 9s. 6d. net.]

DR. CADY'S "General Chemistry"—"something of an abridgment and much of an amplification of his 'Inorganic Chemistry,'" as the author states in his preface—seems to be intended for the general student, whom it may occasionally disappoint. He will hardly learn much from the Fundamental Law of Chemistry that: "Bodies may be arranged in classes such that the different members of each class agree exactly with each other in all their essential properties," and we are not much convinced of the advantage claimed for introducing molar weights, before taking up the chapter on atomic weight, by the words: "The molar weight of a gaseous substance is conceived of as being proportional to the density of the gas. For reasons which cannot be brought out until later, the molar weight of oxygen is taken as 32." The section on gas laws is wedged right into Chapter III, oxygen, in which we are surprised to be informed that oxygen freezes to a "light blue solid." Valence—we should prefer the word valency—is discussed later on, when it is said: "The conception of valence enables us to get easily another useful conception, that of equivalent weight. This is the number of parts by weight of an element . . ." Dr. Cady's language is altogether too easy. Explaining the electrolytic preparation of hydrogen, he speaks of "two pieces of platinum placed in water," and on the same page calcium chloride is described "as a white, very hygroscopic substance which is formed as a waste product in many chemical operations, and is therefore cheap." All that we learn about columbium and tantalum is that they belong to the vanadium sub-group—which is characterised—the metals of which combine vigorously with oxygen and have high melting-points, and that these two metals are very rare and hard to separate, that their principal compounds are the columbates and tantalates, and that their atomic weights are 93.5 and 181.5. Not a word on application, though applications are mentioned in other cases. Titanium, we see, is abundant, but "its compounds are not collected in great beds like the coal beds, so it is not as available as carbon." In the Table of International Atomic Weights the element holmium is missing, and cæsium is spelt cesium; the point may not appear worth mentioning, but we should like to maintain uniformity in International Tables so far as still possible. The octavo volume of 522 pages certainly has its good points. A little more general care would have made that adjective applicable to the whole book.

BOOKS RECEIVED.

The Flying Book, 1917 Edition. Edited by W. J. WADE London: Longmans, Green and Co. [Price 3s. 6d. net.]

Industrial Alcohol. By ROBERT N. TWEEDY. Reprinted from "Better Business." Dublin: The Co-operative Reference Library, The Plunkett House.

All the World's Aircraft (Originally known as "All the World's Airships") (War Flying Annual). Founded by the late FRED. T. JANE, Founder and Editor of "Fighting Ships," &c. Edited and compiled by C. G. GREY, Editor of the *Aeroplane.* Eighth year of issue. London: Sampson Low, Marston and Co., Limited.

Western Australia, 1916. Report of the Department of Mines for the Year 1915. Perth: F. W. Simpson, Government Printer.

United States Department of Commerce. Statistical Abstract of the United States, 1916. Washington: Government Printing Office.

United States Department of Labour. Workmen's Compensation Laws of the United States and Foreign Countries. Washington: Government Printing Office.

A Manual of Field Astronomy. By ANDREW H. HOLT. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 6s. net.]

United States Bureau of Mines. Technical Paper 106. *Asphyxiation from Blast Furnace Gases.* By FREDERICK H. WILLCOX. Washington: Government Printing Office. [Price 15 cents.]

United States Bureau of Mines. Bulletin 124. *Sandstone Quarrying in the United States.* By OLIVER BOWLES. Washington: Government Printing Office. [Price 25 cents.]

Canada Department of Mines. Bulletin No. 17. *The Value of Peat Fuel for the Generation of Steam.* By JOHN BLIZARD, B.Sc. Ottawa: Government Printing Bureau.

Bureau of Mines: Department of the Interior, U.S.A. Technical Paper 87; Petroleum Technology 21. *Methods of Testing Natural Gas for Gasoline Content.* By G. A. BURRELL and G. W. JONES. Technical Paper 163; Petroleum Technology 38. *Physical and Chemical Properties of Gasolines Sold throughout the United States during the Calendar Year 1915.* By W. F. RITTMANN, W. A. JACOBS and E. W. DEAN. Technical Paper 138. *Suggested Safety Rules for Installing and Using Electrical Equipment in Bituminous Coal Mines.* By H. H. CLARKE and C. W. MEANS.

THE HEROULT ELECTRIC STEEL FURNACE.—Licences for the installation of nine Héroult electric steel furnaces have recently been issued by the United States Steel Corporation. Four, of 6 tons, and one, of 1 ton, are for private companies; three, of 6 tons, are for the Government's new projectile plant at Charleston; and one, of 6 tons, for the Naval Gun Factory, Washington. These, says *The Iron Age*, bring to 134 the number of Héroult furnaces operating or contracted for in the United States and Canada.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XVIII.

By JOSEPH HORNER.

THE services of a shop are so intimately related to the character of its product, and so associated with the manufacturing methods which are most suitably adapted thereto, that the general arrangements and the organisation of the numerous details must be worked out without a too slavish regard to the systems which exist in other shops. That system and that equipment which are admirably suited to a works of one character may be wholly unsuited to another factory or shop in which a different class of manufacture is carried through, and where the machine-tool equipments and the systems of production which are adopted are of a different kind. This distinction has been already stated, but it may be amplified in its details with advantage.

The primary distinction between shops is that of the massive character of the work done which marks one extreme, and the minute and highly repetitive nature of the product at the other. Some of the characteristics of each are shared in those works where the articles manufactured are of medium dimensions and where the output is moderate in amount. In many works all classes are included in a number of related shops or associated departments, in which case the lay-out of the shops will be varied accordingly. For the first-named type of shop good crane services are essential. For the second, the transport trucks, the boxes, and stands described in the last article afford the best services. The question of industrial tracks is also answered differently. Where heavy erecting is being carried on in large shops, equipped with overhead travelling cranes, tram rails are less desirable than they are in those shops where the machining done is of medium dimensions, and where erecting or assembling is relegated to related departments or buildings. Tracks may interfere with and hamper the work of heavy tooling and the movements of erectors. The increasing employment of portable shop trucks is having a marked tendency to displace the light railways and the overhead trolley tracks from the monopoly of favour which they have so long enjoyed. And these are most intimately associated with the use of stock or tote boxes, and tool-boxes and stands in which materials, finished parts, tools and appliances are transported between the machines, or the shop stores, or the tool-room and the machines. The portable and the fixed stands, also made in increasing numbers and in various forms, supply a variety which provides for all the conceivable requirements of shops working under diverse systems of manufacture.

In many establishments the machine and the fitting areas are included in the same bay, an arrangement which is especially convenient in the heavier class of manufacture. The machines occupy the sides of the shop, and the fitting and erecting are done in the central areas. In such arrangements the overhead travelling crane affords the principal or the only help required, lifting the work into and out of the machines, and serving the erectors adjacent. Floor tracks would block the way in these shops, since they occupy a width which may have to be encroached on for large erections. Tracks should, however, enter within the doors, or cross some portion of the shop in order to effect a connection with the yard outside or with other shops. Further, since the component parts of machinery or of engines are mostly of large dimensions—too large to be stacked on any stands, they are of necessity laid or piled on the floor, or on wooden trestles. In these shops, therefore, the amplest floor areas are essential.

A good illustration of a shop bay of this kind is seen in Fig. 164, Plate XX, being one of Messrs. Sulzer's engine shops at Winterthur. Massive machine tools are disposed at the sides and ends. Finished pieces are stacked in groups on the floor, and erection proceeds in the central area. A transverse rail track connects the shop bays. A view in another bay, Fig. 165, next the shop wall, shows Diesel engines in course of erection, flanked with rows of fitters' benches, some being next the wall, others on the opposite side, which is flanked by a machine-tool bay. In both shops ample spaces are left for the movements of the erecting gangs around the stacks of rough and tooled elements, and about the engines in course of building. Work of this kind is too massive to be dealt with by the help of jigs and fixtures and by interchangeable methods. Orders, also, are given singly, or for small sets, though some of the lesser components may be made in batches and stored. Castings and forgings are lined-out, and the tooling is done to the lines and centre pops. Templets for some details—bolt holes chiefly—reduce the work of lining-off. Only the small elements—bolts, fastenings, valves and such-like—can be strictly interchangeable. Galleries are provided for this work.

When, as is usual now in most shops, parts are assembled or fitted in unit groups, all the machines that contribute to the tooling of the several details are located together in a sub-department of the machine shop, and the assembling or the fitting benches are adjacent. By adopting this arrangement the unnecessary transport of parts is avoided, and journeys to the finished stores are saved. The gain may not at first sight seem to be great, but the totals are worth considering in a large works. The practice is adopted in the manufacture of motor parts, in fact some of this work, as that of complete gear-box units, is done sometimes by outside sub-contracting firms. Ball races, now so commonly included in bearings of all kinds, are highly specialised units. In small details of this kind great assistance can be derived from the employment of trucks and bins to transport the parts from the machines to the benches and the units to the stores room, or to the fitters or the assemblers. The times of the operations on each machine must be fixed within narrow limits, and the numbers as well as the kinds of machines selected for group working determined accordingly. The more numerous the operations done on a piece are, the higher are the economies to be secured by the adoption of this system, because it reduces transport movements. Motor cylinders afford examples of this kind, on which boring, facing, milling, drilling, reaming and threading are contributory to the completion of the unit. The economy of grouping the related machines suitably to the sequence of the various operations is apparent. And the economy grows with an increase in numbers manufactured.

In locomotive shops the practice of unit production has long been adopted, but the work so treated has been much more that of fitters than of assemblers. The motion work has always been carried through by a class of fitters who become adept in that alone. The cylinder fitting is done by another group, connecting rods and brasses by another, injectors by another in the brass finishers' shop, and so on through each separate section. These are usually carried through in departments located adjacent to the groups of machine tools where the separate details have been prepared.

The interior of a fitting shop in which unit groups are prepared is shown by Fig. 166, Plate XXI, at Crewe locomotive works. Here groups of the heavier pieces occupy the floor in the gangways between the parallel rows of benches, but the smaller articles are piled on the benches. These occupy an area adjacent to the machine shop, which is seen beyond. The hoisting service is that of single-rail overhead tracks and hand-operated pulley blocks. An arrangement which is usual in locomotive works is shown by Fig. 167, Plate XXI, being the erecting shop at the Crewe Old Works. All the work has been prepared in the departments of the machine and fitting shops, and is brought here to the erectors, whose benches flank one side of the shop next the wall. Since frame plates, boilers and cylinders are massive, an independent balance crane running along standard tracks supplements the service of the two overhead travelling cranes.

FIG. 168. GEAR-CUTTING DEPARTMENT; MESSRS. J. W. BROOKE AND CO., LOWESTOFT.

In vivid contrast with these examples, which are typical of all locomotive-erecting departments, of heavy engine shops, marine shops, heavy pump shops and big crane works, are those to which so much interest attaches of late years because of their association with the jig and fixture and gauging systems, and which now include those that have been appropriated for, or newly built, equipped and organised for, the manufacture of munitions. These two strongly contrasted groups have few arrangements in common. In this connection several shop interiors which deal with small products or with those of medium proportions in large quantities are illustrated. In some of these, stands and racks are seen disposed freely about the floors in proximity to the machines. The products are transported readily without the aid of floor tracks or of overhead cranes. Piles of similar pieces that are too large for arrangement on stands occupy floor areas. It is obvious that the volume of the product which is turned out by a machine must have a paramount influence in determining the character and extent of the services which are clustered round the machine. The quantity in many instances is so large that the storage or stacking service and the transport arrangements must be on a correspondingly ample scale if congestion is to be avoided. At extremes there is a hardly a comparison between the output, say, of a slotting machine, or a standard

lathe, and that of an automatic turret lathe, or a screw machine, or of a specialised grinder. Or between a machine that attempts to rough out with tools of carbon steel and one which employs those of high-speed steel. It follows that the services of storage and of transport must be different in regard to their capacity and facility for handling.

Fig. 168, page 274, shows one of the departments—that of gear cutting—in the shops of J. W. Brooke and Co., Limited, of Lowestoft. The service here is that of various stands and boxes for blanks and finished gears. A worm hobbing machine and a Fellows gear shaper are noticeable in the foreground. This firm is devoted to the manufacture of marine motors driven by petrol or by paraffin, and of motor launches. All the component parts are put through the shops in batches, and sent into the stores, to be issued as required. Parts are tested by limit gauges to interchange.

The view, in Fig. 169, Plate XXII, in the turnery of the Hendey Machine Company shows completed elements and units stacked on the floor areas. In addition, tote boxes are set under the lathes, and strong wooden tables with drawers are provided for the service of the lathes to carry appliances and small pieces of work in progress. Besides the tote boxes and the wooden tables, stands are seen near the foreground which are loaded with assembled headstocks, and others are seen on the floor. These are lifted and transported by the light portable crane seen a little to the left.

A useful form of stand for turneries is built in large numbers to run on castors underneath lathe beds primarily to catch the chips and oil. This is the more necessary now, when the quantities of chips from the high-speed steel tools have increased so enormously. But when the space between the bottom of the bed and the floor will permit, a double design of stand is made to carry a deep tray above and a shelf for appliances and tools beneath. These are made to suit standard lengths and depths of lathe beds to a large range of dimensions. As the designs of lathes now frequently include ample chip pans with drainage tanks, the stands with shelves like those shown in the last article and variously modified are often set down beside the lathes as in Fig. 170, Plate XXII. These carry collets, steadies, tools, spanners, or they may receive completed parts. The shelves have protecting edges to prevent articles from tumbling off. A drawer is often fitted, with a lock, to receive the fine tools and valuable gauges.

Assembling cabinets are used increasingly in shops. They fulfil for the assemblers the same functions that the stands do for the machinists—to avoid loss of time in walking to and fro and waiting, and the misplacing of tools and appliances. They are made with doors and trays, and the trays are filled in the shop stores with the individual components or the units that are necessary for the erection of a machine or of a sectional unit of a machine. Being put into the cabinet, it is run out on a truck to the assembler. One advantage of the use of these cabinets, in addition to the convenience of having all the small parts located handily in one receptacle, is the duplication of the trays. Having a second set of trays with each cabinet, the storekeeper can be preparing one set of fittings during the period while the other set is in use, and thus avoid delays.

Two views, on Plate XXIII, taken in the Burnage shops of Messrs. Hans Renold, Limited, of Manchester, are remarkable as showing the absolute preservation of the central gangways from encroachments. But the whole of the work done is of very small dimensions, produced in enormous quantities, all gauged and strictly interchangeable. Each machine has its own receptacle for screws, pins, rollers, &c., some of which are visible in Fig. 172, so that nothing is allowed to occupy the floor. Another arresting feature is that chain driving is adopted, to the almost complete exclusion of belt drives. Also a uniform system of girders is installed to which the shaft bearings are attached, and along which they can be adjusted readily. In Fig. 171 a wide aisle is flanked by wire-grinding machines and chain-part stores in the foreground on the left, and by automatic turning machines on the right.

Fig. 172 is a shop with automatic lathes, in which chains drive from motors to line and to countershafts, and thence to the lathe spindles in the case of the larger machines. There are four of these bays, 20 ft. wide from pillar to pillar, with 63 automatic lathes arranged in four rows, driven by two line shafts and four rows of countershafts.

The shafts in this works are standardised throughout, and are of liberal dimensions to avoid risks of twisting and bending. The line shafts are all 3 in. in diameter, running in self-oiling hangers, with swivel cast-iron bearings, which are situated 10 ft. apart. All the fittings—the couplings, hangers, drums and sprockets—have the same bore, which facilitates the making of rearrangements involved in extensions and the laying down of new machines, and is favourable to the manufacture of the parts.

Messrs. Renold state that motor chains will last for six years and countershaft chains from six to ten years, and that they are preferable from various causes to belts. Power is saved. As there is no slip, production is increased, the wear and tear on countershafts is less than when leather belts are used, the wear of tools is reduced, and better work is done. It must be remembered that in chain production the parts are all small, and all have to be produced in large quantities within fine limits, so that any unsteadiness in driving becomes revealed in results.

Another aspect relates to the blocking of light. Chain sprockets are smaller in diameter by one-half than belt pulleys, and narrower by one-half or less than pulleys doing the same work. And instead of fast and loose pulleys, and belt forks, friction-clutch sprockets are used. This is shown in Fig. 173, which illustrates two clutches, and sliding cones between, operated by a cord from below. This is the standard two-speed arrangement. The chains to the right are seen driving from the line to the countershaft, and the chain to the left going to the machine. The standard girders along which the hangers are adjusted are seen overhead. The driving from the motors to the line shafts is seen in Fig. 172.

Figs. 174 and 175 show two arrangements recommended for chain-driven line shafts. Fig. 174 is that seen in the automatic turning department in Fig. 172, except that in the latter a separate motor is assigned to each line shaft. In Fig. 175 a single motor drives successive line shafts at equal speeds of 120 r.p.m., but with diminishing efficiencies. As is generally known, the method of chain driving has been adopted in a good many instances for operating the feeds and other movements of machine tools in preference to the employment of belts, and the use of chains will doubtless extend.

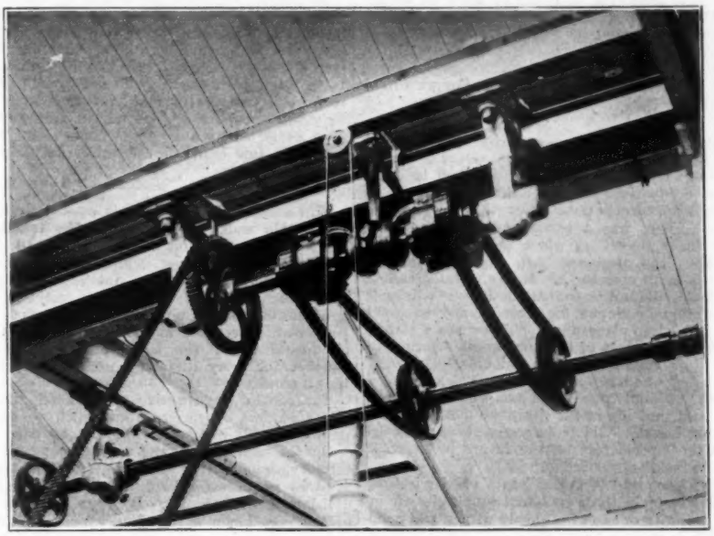


FIG. 173. CHAIN-DRIVING ARRANGEMENT OF TWO-SPEED COUNTERSHAFT ON THE RENOLD SYSTEM.

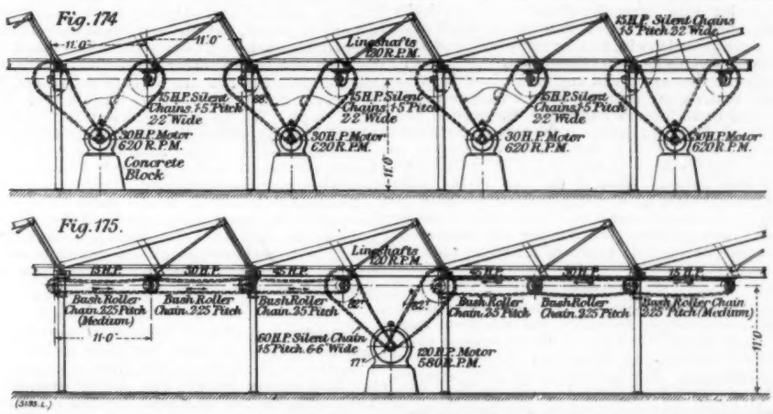


Fig. 174
11'0"
11'0"
Line shafts 120 R.P.M.
15 H.P. Silent Chains 15 Pitch 2·2 Wide
75 H.P. Silent Chains 1·5 Pitch 2·2 Wide
30 H.P. Motor 620 R.P.M.
Concrete Block
Fig. 175.
15 H.P.
30 H.P.
55 H.P.
Bush Roller Chain. 2·25 Pitch (Medium.)
Bush Roller Chain. 2·25 Pitch
Bush Roller Chain. 3·5 Pitch
60 H.P. Silent Chain. 1·5 Pitch. 6·6 Wide
120 H.P. Motor 580 R.P.M.

FIGS. 174 AND 175. ALTERNATIVE SYSTEMS OF THE RENOLD MOTOR-DRIVEN CHAIN TRANSMISSION; MESSRS. HANS RENOLD, DIDSBURY, MANCHESTER.

PROHIBITED EXPORTS.—The supplement to *The Board of Trade Journal* of September 6 contains complete lists of articles which, according to the latest information received by the Board of Trade, are prohibited to be exported from Norway, Portugal, Russia, Spain, Sweden and Switzerland. The supplement also contains a reprint of the United Kingdom Contraband List in its present form. Copies may be obtained at a cost of 3*d.* (3½*d.* post free), either from any bookseller or from His Majesty's Stationery Office, Imperial House, Kingsway, London, W.C. 2.

INDUSTRIAL NOTES.

THE secretary of the Ministry of National Service announces that the Minister of National Service has, by arrangement with the Minister of Labour, appointed Sir Herbert Edward Morgan, K.B.E., as Deputy Director-General of National Labour Supply.

The Trade Union Congress continued its sittings at Blackpool on Thursday to Saturday of last week, 6th to 8th inst. We select the following points from among the proceedings of the three days :—

A resolution was passed declaring for demobilisation based upon mutual co-operation of the trade unions with the employers' associations, for the maintenance of returned soldiers and the setting-up of training quarters, and affirming the necessity of a Bill establishing a legal eight-hour day or 48-hour week. Another motion provided that all workers displaced through reinstatement or through the closing down or changing of existing works, and all men who, owing to injury on active service, were not physically capable of performing the duties on which they were engaged previous to the war, be either found remunerative employment or pensioned.

The question of the demobilisation of women in industry was put forward by the National Federation of Women Workers. The proposals included extension of employment insurance and a month's furlough with full pay to workers in munitions and other trades in which there had been excessive overtime.

In the matter of Free Trade, the following resolution was passed by a large majority : "That in the opinion of this Congress the economic conditions created by the war have in no way altered the fundamental truth that Free Trade between the nations is the broadest and surest foundation for world prosperity and international peace in the future ; that any departure from the principle of Free Trade in this country would be detrimental to the interests of the working classes, on whom the burdens of Protection would press heavily, and injurious to the prosperity of the nation as a whole ; and that Protectionist duties, by adding to the cost of the people's necessaries, are unjust in incidence and economically unsound, subsidising capital at the expense of labour. This Congress therefore instructs the Parliamentary Committee to take the necessary steps to lay the views of this Congress before the Prime Minister."

With reference to food prices in this country the Congress passed a resolution to the effect "That this Congress, representing the organised workers of Great Britain, expresses its regret at the long delay of the Government in taking such action as would prevent the continued rise in food prices. It believes that the Government has failed to give proper attention to the grievances which the masses of the people are suffering under by reason of the enormous and unjustifiable increase in the cost of living. It instructs the Parliamentary Committee to place before the Government and the Labour Party the necessity of immediate steps being taken for the purchase by the Government of all essential food-stuffs, the commandeering of ships, the controlling of freights and all home products. It views with alarm the enormous increase in the price of food since August, 1914, and expresses its profound astonishment and indignation that, in view of the fact that the increased price is to a large extent due to the action of shipowners and others in charging exorbitant rates for transport, the Government have not completely taken over the direct control of shipping, railways, and all means of transport in order to ensure for the people wholesome food and the general necessaries of life at the lowest possible charges, and now calls upon the Government immediately to adopt measures to attain that end by taking over all means of transport, together with full control of home food production, and also fixing a maximum price for food and all other commodities essential to the life and best interests of the nation.

"This Congress claims that the Government shall control the imported and home supplies of and the prices charged for wheat and coal, and all other necessaries of life during the period affected by the war with due regard to the purchasing powers of the workers. In case the reply of the Government is not satisfactory a special National Conference organised by the committee and the National Executive of the Labour Party be convened, at which drastic steps should be recommended, because wage advances are of no service if the cost of living rises so continuously."

At this point Mr. J. R. Clynes, M.P., the Parliamentary Secretary to the Ministry of Food, explained that much of what was demanded in the resolution had been taken in hand and was in a fair way towards realisation. He added that Lord Rhondda, in dealing with the problem, was having regard only to the rights and interests of the consumers and the great masses of the working-class population.

Among the resolutions passed at the last meeting, on Saturday, the 8th inst., was one expressing hearty approval at the formation of a Ministry of Labour. The resolution also welcomed the appointment of advisory committees to assist in the work of Employment Exchanges, provided they are collectively nominated by the bodies to be represented, and the duties assigned to these committees are extended so as to give them a real opportunity of rendering service. It also approved the proposed extension of the Trade Boards Acts to several other trades, on the lines of the resolution passed at the Birmingham Congress last year.

Another resolution asked for the amendment of the Factory and Workshops Act by requiring the issue of a certificate of fitness from a factory inspector before any factory or workshop is used for the manufacture of articles ; in the case of females a certificate from the Home Office that it is a fitting occupation for women or girls ; the reduction of hours of work to 48 per week ; abolition of all fines and deductions ; further restrictions on payment by truck ; a large increase in the number of women factory inspectors ; and the extension of the Acts to cover offices.

It was unanimously decided that the Congress next year be held at Derby.

Civilians were wont to say, writes "A Cadet" in *The Manchester Guardian*, that the war would have the effect of making soldiers who had followed sedentary occupations in peace-time disinclined to return to such occupations after the cessation of hostilities. There was a certain amount of plausibility in the argument on which this statement was based. Men, the argument ran, who had become accustomed to an open-air life during training and in the trenches would not be content to sit on office stools or stand behind counters, or serve in any enclosed place or in a close atmosphere. There was a strong presumption that most of the men would "return to the land" or emigrate to the colonies. The very important fact was left out altogether that a "return to the land" was only possible to men who had quitted the land, and that life in the country for a city clerk or a shop assistant would be unprofitable and uncongenial. Other speculators on the future professed a belief in the future of soldiering.

The experience of "A Cadet" as a soldier is that the people who make these confident prophecies are in the great majority of cases hopelessly wrong, and none are so much in error as those who declare that masses of men will decide to continue in the army after the war. The whole outlook of the men is a civilian outlook. Roughly speaking, the new soldier is a home-loving man, strongly rooted to a particular place, and possessed of certain social habits which come from easy association with various people, and especially with women whom he loves and respects.

The writer has not found any enthusiasm for a life on the land among soldiers, even among men who were bred to it. Broadly speaking, the soldiers may be divided into two groups : (*a*) those who intend to return to their civil occupations as quickly as possible, and (*b*) those who are in a state of indecision about their future. Most of the men in the latter group speak vaguely of emigrating to Australia or America. A great many of them will probably emigrate, but an appreciable fraction will, after many fluctuations of opinion, decide to return to their old jobs.

We are informed that the Johannesburg Miners' Union have resolved to accept the minimum wage offer made by the Chamber of Mines, subject to an agreement regarding the interpretation to be put on certain passages. The miners' union have accepted a 48½-hour week from bank to bank, to date from January 1 next, and an additional war bonus to start from the 1st inst. They declined, on the other hand, the offer of the Chamber of Mines to establish an employment bureau.

According to an announcement issued by the Bureau of Statistics and Information of the New York State Industrial Commission, the light, heat and power industry increased both its number of employees and its wage payment 5 per cent. in June, as compared with May. As compared with June of last year, there were 7 per cent. more workers and 13 per cent. more paid in wages.

We read in *The Iron Trade Review*, Cleveland, O., that an announcement issued by the Pennsylvania Railroad of its intention to waive its rule of employing men not older than 45 years, and, for the period of the war, to accept for employment men up to 70 years, indicates an innovation to meet present exigencies which doubtless will be adopted by many industries. Like the employment of women in shops, the positions thus opened by no means are assured as permanent. Needless to say the removal of the age restriction places the man over 45 on an equal basis *pro tem.* with the more aggressive worker of 30, but if conditions should return to a pre-war basis, employers will be less likely to overlook the shortcomings of the older man than they are at present, when labour is unusually short. The mere fact that the announcement is made as a war expedient reveals a cautionary tendency on the part of the railroad against a time when labour again will become plentiful.

The same American journal asks whether the art and science of steel salesmanship is to become lost or blunted through non-use. In the present situation this appears to be a live question, and the answer seems to depend, like many other questions at present, on the uncertain duration of the war and resulting conditions.

At present the steel salesman is not selling ; he has nothing to sell. His employer, who formerly commended him when an order was landed, now berates him when he has not been sufficiently adroit to sidestep effectively the importunities of a buyer. He is being retained on the pay-roll not to get business but to keep it away. His main function is to keep the inquiring consumer in good temper and at the same time avoid taking an order. There seems to be real danger in this both for the individual salesman and for the business.

The mind of the engineer is essentially a creative mind. He walks warily among the teeming possibilities which surround him. He looks to the future more than to the past, while he does not despise precedent—more often than not he creates precedent by further advance. He adapts, adjusts, revalues and selects from among innumerable expedients the particular process or method which suits the exact circumstances of the case. He has no universal panacea for every difficulty, no specific prescription for all troubles.

The ideal representative of national affairs, says *The Canadian Engineer*, from which we take these remarks, needs just such a mind as outlined above.

On the other hand, the average lawyer's mind is dilatory, bound with red tape, tied with precedent. It does not create, it takes advantage of minute divisions and side issues. It is bound by the shackles of the past in an extraordinary manner. It cannot organise, and its achievements are verbal triumphs, not executive deeds. Yet it is the lawyer who predominates in public affairs, to the public disadvantage. That there have been fine minds in the legal profession, able to separate their legality from their publicity, cannot be denied, but the question at issue is whether they could have been greater public utilitarians had their training been in some other profession. Governmental administration is not the working out of detail, but the provision of broad tolerances wherein the individual finds scope. The lawyer is deficient in this business view. Keeping within the exact letter of regulation to avoid trouble, while adopting a policy which hampers its spirit, is too prevalent in governmental departments all the world over.

No engineer could do his best under such control ; he must have a free hand within his limits. And this forms another link in the chain of reasons why engineers should be in positions of public authority in administrations, rather than under the complete rule of the political-legal mind.

Following a conference between representatives of American seamen and their employers, assisted by the Departments of Commerce and Labour, an agreement has been signed, reports *The Marine Journal*, New York, fixing the following scale of wages : Sailors and firemen, 60 dols. a month ; coal passers, 50 dols. ; oilers and water tenders, 65 dols. ; boatswains, 70 dols. ; carpenters, 75 dols. Overtime pay for cargo work will be figured at 50 cents an hour, and for shop work at 40 cents. A 50 per cent. bonus will be paid to crews entering the war zone, and employers will pay seamen 100 dols. each compensation for loss of personal effects when ships are sunk.

The scale of wages and bonus for stewards and cooks will remain unchanged for the present. It was also agreed that this wage scale shall remain in force during and for a year after the war, but that bonuses and other compensations arising during the war shall terminate with it. Every ship will carry a certain number of boys in its crew to increase the number of men available for future developments.

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE.—This school has issued its programme of lectures and classes for the session 1917–18. Among these are lectures and classes on railway and cognate subjects, which commence on Thursday, October 4. Further information can be obtained at the school, Clare Market, Portugal-street, Kingsway, W.C. 2.

THE LATE MR. JOHN HENRY KNIGHT.

We regret to have to announce the death, which occurred on Saturday, the 8th inst., at his residence, Barfield, Farnham, Surrey, of Mr. John Henry Knight.

Mr. Knight was born in 1847, at Farnham, and was brought up as an engineer. He was one of the pioneers in motor car construction, having constructed, in the year 1868, in the workshop which he put down at Leybourne House, Farnham, a steam carriage, supplied with steam from a vertical multitubular boiler, and which he provided, in the first place, with a single-cylinder engine driving by a chain one of the rear road wheels. Later on he fitted this carriage with a Field boiler and a two-cylinder engine. This carriage was used for several years on the roads in the Farnham district. He continued his experiments with his "Trusty" oil engine, and in 1895 he built the first oil-driven car made in England. This was a three-wheel vehicle, fitted with a 1 h.p. engine and carrying two persons. The Motor Car Act being not then in existence (it was only passed a year later), Mr. Knight was summoned before the Farnham Bench and fined a small sum for driving it down Castle Hill without having a man walking in front and carrying a red flag.

Mr. Knight was one of the founders of the Self-Propelled Traffic Association, and of the Automobile Club, which later became the Royal Automobile Club; he was for several years on the committee of the latter. He was the author of various books on motor cars.

FERRO-CONCRETE SHIPS IN ITALY.—We read in *L'Industria*, Milan, that a company, the Societa Anonima Navi Italiane Cemento Armato, "Nica," with offices in Rome and works in Genoa, has been formed, with a capital of 1,000,000 lire (40,000*l.*), to be raised ultimately to 5,000,000 lire (200,000*l.*) for the construction of ships, particularly ferro-concrete ships.

IRON AND STEEL INSTITUTE.—In addition to the list of papers announced in the programme of the autumn meeting (see under Notices of Meetings), Committee No. 3, for the manufacture of open-hearth steel, will present reports on "Metallurgical and Mechanical Practice in Open-Hearth Steel Works," in which British and foreign practice is compared. It has been arranged to hold a special session at 3 p.m. on Thursday, September 20, for the purpose of discussing these reports. The paper No. 6 in the original programme, by Mr. E. F. Law, on "Effect of Mass on Heat Treatment," cannot be ready in time for the meeting, and is deferred to a future occasion.

AMERICAN "SEA ROVERS."—According to *The Marine Journal*, New York, destroyers are building in unannounced numbers at certain great shipyards of the Atlantic coast; fine, powerful cruisers, of 300 ft. or so in length, fit to race and fit to fight, carrying not only a quota of torpedoes, but a smart battery of rapid-firing guns. The first torpedo-boats were slight and puny craft; these modern destroyers are veritable ships in their dimensions. They are capable of keeping the seas for a long time in tolerable comfort, as witness the ease with which some of them have slipped across the western ocean to "do their bit" for France and England against the submarine blockade.

SHIPBUILDING IN JAPAN.—Steel plate shipments to Japan, says *The Iron Age*, New York, have been an outstanding feature of the phenomenal American war exports. Quick to perceive the profit to be made out of merchant vessels in the face of a wholesale destruction of shipping, the Japanese have been concentrating every energy on shipbuilding. They have seen that the earning power of a steel vessel for several years after the war would far more than compensate for its present high cost. Paying as high as 11 cents and 12 cents. per pound for American plates delivered in Japan, their absorption of this material has been the outstanding feature of the plate market. The export to Japan has increased from only 7,250 gross tons in 1913 and 3,275 tons in 1914, to 89,458 tons in 1916. For the ten months ended April 30, 1917, Japan's share of plate exports was 138,565 tons, or nearly 50 per cent. of the total. The movement is a striking example of Japanese business acumen.

ITALIAN FLYING RECORD.—From Turin to Naples and return, without a landing, constitutes the world's long-distance aeroplane record, recently established by Captain Julius Laureati, of the Italian service, says the Fiat Company. In an absolutely straight line the two Italian cities are 450 miles apart, but on the route followed, and making allowance for drift, the actual distance covered by the Italian machine was not far short of 1,000 miles. Captain Laureati made the trip on a new type of Sia biplane, built in Turin, fitted with a water-cooled engine built at the Fiat factory, in the same city. The time occupied was exactly 10 hours 30 minutes, which gives an average speed of not much less than 90 miles an hour. Although weather conditions were good on the outgoing trip, the aviator had to contend with a head wind and generally unsatisfactory weather conditions on the return journey. This performance, which constitutes a world's record, is remarkable proof of the reliability of the Fiat engine and of the efficiency of the new aeroplane.

WORKSHOP TRAINING OF APPRENTICES.

TO THE EDITOR OF ENGINEERING.

SIR,—Our attention has been drawn to the article which appeared recently in ENGINEERING on this subject. We should like to state that we have for a number of years adopted several ideas discussed in your issue of June 22 under the above heading.

Supplementing Mr. Maclean's article on pages 583 and 584 of the issue just named, we may indicate some of the methods in use for training apprentices in this factory. In normal times we have apprentices in some twenty departments—in small numbers, naturally, because the skilled trades carried on at Bournville are subsidiary to the main business. The departments in which apprentices have been trained on these lines include tool-making, fitting, tinsmithing, pattern-making, carpentry, printing, bookbinding, plumbing, and a number of others.

The practical training of these youths is regulated pretty definitely by the provision of departmental syllabuses, typed copies of which are exhibited in the shops as well as supplied to both foremen and apprentices. The syllabus sets out the classes of work which should, as far as is practicable, be done by an apprentice during each year of his training, though of course it does not aim at being an exact time-table, in the same sense as a time-table would be followed in a college workshop.

Annual trade examinations, both written and practical, are held by external examiners who are appointed by the firm, generally on the recommendation of the trade union concerned. The practical tests are carried out in the firm's workshops, in the presence of the examiner. Each examiner submits a full report to the Works Education Committee.

Our period of apprenticeship being from 16 to 21, the scheme has been seriously dislocated by the war, but the results obtained in normal times were such as to suggest that the methods outlined above are well worthy of wider application. Our experience seems also to confirm many of the points made by Mr. Maclean in his valuable article.

Yours faithfully,
CADBURY BROTHERS, LIMITED.

Education Department, Messrs. Cadbury Brothers, Limited, Bournville, September 11, 1917.

CORROSION OF CONDENSER TUBES.

TO THE EDITOR OF ENGINEERING.

SIR,—Whilst thoroughly appreciating your correspondent, Mr. W. Ramsay, in his efforts (see page 209 of your issue of August 24) to substantiate my claim definitely to overcome corrosion of metals in contact with liquid, I feel it my duty to enlighten him (and possibly others of your readers) on some important points. For instance, I cannot comply with Mr. Ramsay's suggestion to eliminate from my list of the causes of corrosion the terms "chemical" and "mechanical," and substitute the term "mythical," for the simple reason there is nothing mythical about this subject.

Mechanical action will cause galvanic action, and galvanic action is the prime cause of chemical action. Further, one must bear in mind that the dissimilarity which produces galvanic action may either be physical or chemical. It is a well-known fact that mechanical forces considerably affect the crystalline structures of metals.

To make it quite clear: to test the hypothesis procure a strip or plate of metal and cut it in half, then test the relative galvanic effect of the two pieces when immersed in an electrolyte through a sensitive galvanometer, and note how slight, if any, difference of potential exists. Then submit one piece to rough treatment by bending or hammering, and on testing again it will be found that the piece which has been mechanically treated will be decidedly electro-positive to the normal piece. The amount of chemical decomposition will be in exact proportion to the galvanic action that takes place.

Many inventors of so-called "perfect alloys" have failed through losing sight of this fact. Their article, when produced and tested under laboratory conditions, resisted ordinary corrosive action, but when used commercially and subjected to rolling, flanging, riveting, machining, &c., proved little better and in some cases even less serviceable than the 70 : 30 mixtures of copper and zinc.

One very remarkable instance which may be fresh in the minds of many of your readers is the American yacht Sea Foam, built at Nantucket, U.S.A., whose hull and deck fittings were wholly composed of M——l metal. This ship was condemned as unserviceable in less than six months from being launched; this was entirely due to the ravages of corrosion.

The explanation, of course, lies in the direction referred to, viz., that no metal can remain homogeneous when submitted to stresses of manufacture and service conditions.

There are many scientists of to-day who lose sight of this highly important fact and cling to the frail hope of producing a non-corrosive metal. Much as I would like to oblige our ardent friend, I must still persist in using the term "mechanical" and not "mythical."

Mr. Ramsay may have seen a somewhat similar system tried 25 years ago, and I would be pleased to learn more about the experiment, but it was decidedly not the "Cumberland" process, which has been proved practical and has not been discarded; and, moreover, has won a good and lasting reputation in the mercantile and naval services of some years' standing.

Mr. Ramsay cannot be *au fait* with my system when he says that I create an artificial back E.M.F. just sufficient to polarise the surfaces to be protected; this would be quite impracticable. My system is to apply an E.M.F. of much higher potential than that causing the corrosion. The current supplied is from 6 volts to 15 volts pressure, with ample volume or amperage to coat the whole of the immersed surface to be protected with hydrogen.

Though scientists were to succeed in discovering a metal that is acid-resisting, that is not to say the metal would be non-corrosive, for it is against Nature's law for any metal to withstand electrolysis, whether electrolysis be caused from local action or from a secondary source such as a stray leak from electrical mains.

The only way to overcome this is to oppose the same to the method described above and transfer all corrosion, no matter how caused, to an auxiliary anode; this is a simple, cheap and expeditious way of overcoming the whole trouble.

Yours faithfully,
ELLIOTT CUMBERLAND.

6, Lloyd's-avenue, London, E.C. 3, September 10, 1917.

METRIC SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—The discussion you have most sensibly invited on the above subject will be, I am afraid, well finished before this letter reaches you. Nevertheless I feel it my duty to support our representative.

We are, because of our habit of purchasing from all countries, very well acquainted with the metric system of measurement at least. The foremen and many of the workmen of most engineering establishments carry a rule marked both in metres and inches, and use either system with equal ease. As further proof of our preparation for its adoption here in Australia, I must state that the system is being taught in the trade classes of our technical schools. Thus, you see, if you move, we are ready to respond.

The change, I must admit, will cause, as all changes do, temporary inconveniences, but these will be far outbalanced by conveniences and economies—physical and mental—introduced by the simplicity of the system.

Yours faithfully,
ROBT. W. WIMMITT,
Technical Trade Instructor and Departmental Foreman, Melbourne Electrical Supply Company, Melbourne, Australia.

Sunshine, July 7, 1917.

COAL PRICES.—The Board of Trade has issued an order and instructions dealing with coal prices. The order, dated the 5th inst., applies to coal purchased by railway companies in Great Britain for consumption on locomotives and for other purposes, to coal consumed in national factories, in gas and electrical supply undertakings, and to coal sold to retail merchants. The instructions, dated the 6th inst., are issued by the Controller of Coal Mines, Board of Trade, and govern the pit price of coal for consumption in the United Kingdom.

"THE MUNITION WORKERS' HANDBOOK."—The second edition, revised and enlarged, of "The Munition Workers' Handbook," by Mr. Ernest Pull, A.M.I.Mech.E., R.N.R., M.I.M.E., is now issued at the price of 2*s.* 6*d.* net by Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate Hill, E.C. In this edition chapters have been added on milling machines and milling, and on gear-cutting, which increase the scope of usefulness of the book. It is, like the first edition, most carefully got up, and contains a large amount of information, clearly stated and illustrated, in a very handy form.

THE TINPLATE INDUSTRY IN GERMANY.—According to a statement in a recent issue of the *Frankfurter Zeitung*, quoted in the Board of Trade Journal, efforts are being made towards the formation of a syndicate in the German tinplate industry after the war. The former tinplate syndicate was dissolved in 1914, but it is stated that German tinplate manufacturers are of opinion that a strong organisation cannot permanently be dispensed with. It is thought that only by means of such a syndicate will it be possible to solve certain economic problems, particularly in connection with Customs policy. In former times, it is said, the United Kingdom to a large extent supplied the German tinplate demand, but in recent years the tinplate industry in Germany has been so strengthened that it is expected that it will be able to export large quantities of tinplates immediately on the return of normal conditions.

MANUFACTURE OF MINERAL WOOL FROM BASALT ROCK.—According to a recent issue of the Melbourne *Age*, an extract from which has been forwarded by H.M. Trade Commissioner in Australia to the Board of Trade, a pure white mineral wool is being manufactured at Yarraville, a suburb of Melbourne, from basalt rock, or "bluestone," vast masses of which are found in the neighbouring Footscray district. This is a new industry in the Commonwealth, and has been started by an American firm. The mineral wool has a staple of about 1¼ in. to 2 in. It is said to be pure white with a fine metallic lustre showing through it, and in texture it is soft and pliable. It is easily adapted for engine packing, and is already in use in the Yarraville factories. It can also be moulded into sheets like asbestos. Only the shortness of the staple militates against its use for weaving. There is said to be an increasing demand for this product as an insulator for packing machinery or ice-chests, and as a substitute for asbestos.

RECENT DEVELOPMENTS IN AIR PUMP DESIGN.*

By MR. E. JONES.

(*Concluded from page* 265.)

The British Westinghouse Electric and Manufacturing Company, Limited, Manchester, and the firm of Messrs. The Mirrlees Watson Company, Limited, Glasgow, manufacture an ejector air pump, under licence from the Société Anonyme Westinghouse, Paris and Le Havre, which is another invention of Monsieur Maurice Leblanc. It is the outcome of many months of arduous research work, during which time innumerable difficulties were surmounted by the inventor, with the result that a really first-class ejector air pump has been evolved. Figs. 10, 11 and 12 show the general arrangement of this apparatus. It will be noticed that the pump is arranged to work in two stages, and the steam is admitted to the second stage of the ejector by opening the stop valve C. Immediately C is opened steam fills the annular space behind the nozzle plate, and finds its way into the throats of the group of nozzles attached to this plate; it then passes along the steam pipe which supplies the first-stage nozzles, which are also attached to a nozzle plate. The supply of steam in this set of nozzles is controlled by the stop valve on the steam-supply pipe. The pump is connected to the condenser at the branch D, which is the air-inlet branch. At the entrance to each of the steam spaces fine wire-gauze strainers are fitted to prevent any foreign matter, which may have primed over with the steam from the boilers, from entering the nozzles, thereby intercepting any stoppage in the nozzle throats, and consequently a loss of vacuum. These nozzles are efficiently locked to the nozzle plates. The mixture of air and steam is discharged at the mouth of the divergent cone Y, and led away to the boiler feed-tank, so that the heat units contained in the operating steam can be reclaimed by heating the feed water. To start the pump to work it is only necessary to open up the steam valve C, and the vacuum will at once commence to increase in the condenser or other vessel to be evacuated. When the vacuum gauge becomes stationary the second-stage steam-inlet valve is opened up to bring the vacuum to a maximum. A very important feature in this pump is the absence of moving parts. The simplicity of the apparatus is even more remarkable than that of the Leblanc rotary pump.

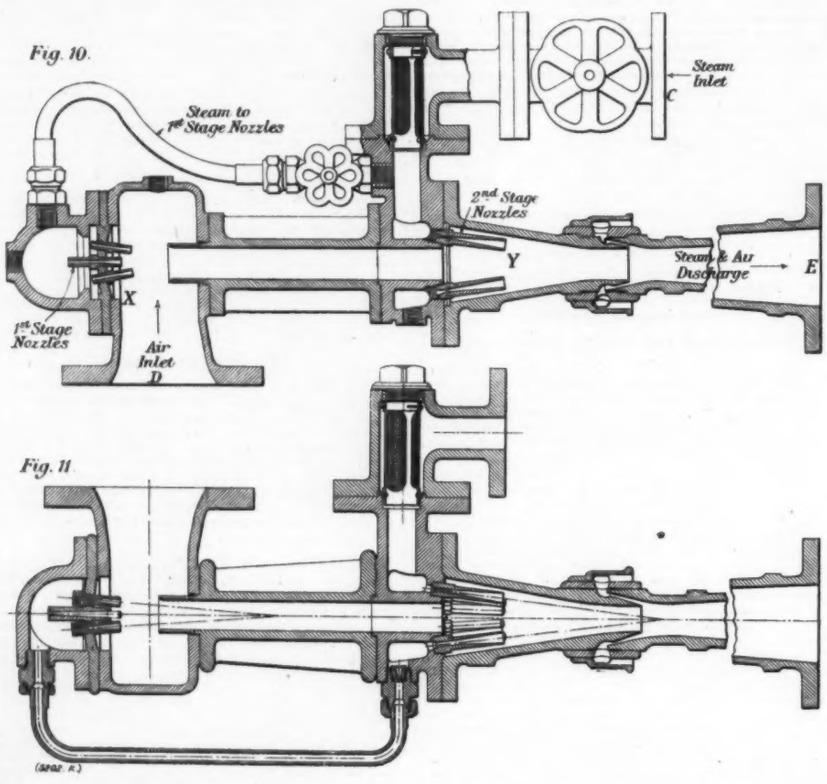


Fig. 10.

Fig. 11.

The advantages claimed are as follow: (1) extreme simplicity; (2) the small amount of energy required for operating purposes; (3) the high efficiency obtained. (4) ease with which starting can be effected, and the small amount of attention required whilst at work; (5) ability to produce the highest possible vacuums; (6) stability. In scanning these claims we can pass over the first, which, as already mentioned, is obvious; there are simply two steam valves to open. The second deserves some consideration. The operating steam in passing through the nozzles decreases in pressure, and consequently in temperature, and also, after passing through the nozzles, does work in accelerating the velocity of the air, increasing its temperature and compressing it. There is also a small amount of heat lost due to friction in passing through the diffuser portion of the ejector, which might be considered negligible. Beyond this, the whole of the heat in the steam can be utilised to heat up the boiler feed-water, and in order to obtain full benefit from the apparatus it is highly desirable to use the discharge from the ejector for heating purposes of some description. Thus both the steam and air can be made to do useful work. In view of this, it must not be forgotten that when an ejector of this type is specified as requiring so many pounds of operating steam per hour, this is only the apparent quantity, the actual quantity is really far less, since the great majority of heat units in the steam are still available for further work. The actual heat units recovered can easily be calculated from steam tables, since it is known that the steam and air leave the ejector at a pressure of from 10 lb. to 12 lb. per square inch by gauge. It will be observed that with a Leblanc multijector an auxiliary condenser is not required, and in this respect it differs materially from the "Breguet" *ejectair*. The employment of an auxiliary condenser has the disadvantage that the total heat units of the steam used in the first-stage ejector, which amount to an appreciable percentage of the total heat units used on the whole apparatus, are dissipated and lost. The makers give this percentage as about 33. Another reason for dispensing with the auxiliary condenser will be apparent from the following. In all steam-operated ejectors one of the difficulties that have to be contended with is the fact that the steam leaves the nozzles at a velocity varying from about 3,000 ft. to 3,600 ft. per second, while the velocity of the fluid to be entrained is practically nil. This is the cause of considerable loss of efficiency in any ejector, but if an auxiliary condenser be used the defect is doubled, because the velocity of the fluid to be entrained, which has been imparted to it by the operating steam during its passage through the first-stage ejector, is dissipated and lost as soon as it enters the condenser. The cooling water used on the auxiliary condenser has to be dealt with by the condensate pump, thus increasing the power absorbed by the plant. When working with surface condensers this water must be of good quality, as it has to be returned to the boilers.

The third claim relates to efficiency. It is well known that ordinary single-stage ejectors only work well when the compression ratio is as 1 : 7, and it is partly for this reason that the Breguet Company have introduced the auxiliary condenser, so that the vacuum obtaining in this condenser is about 25.6 in. with the barometer at 30 in., the compression being approximately as 11 : 76, or, roughly, 1 : 7. The overall efficiency of this plant is, therefore, apparently still further reduced, because air is admitted from the atmosphere into the auxiliary condenser, which is under a vacuum of 25.6 in., and this, together with the air from the condenser, has also to be ejected by the secondary ejector to the atmosphere.

When Professor Leblanc set out to design his ejector he foresaw the possibility of using an intermediate condenser, but he also appreciated its disadvantages, and decided to do without it if at all possible. At the same time he knew that it was essential to use two stages in order to get a stable and efficient ejector. With this end in view, certain steam nozzles were designed on the lines of the formulæ of Professor Rateau, and the action of the steam issuing from these nozzles when under high vacuum was directly observed. The result is shown by Fig. 13. The steam issuing from the mouth of the nozzle expands and contracts alternately, ultimately assuming a section of constant area. It was found that a number of these nozzles grouped together gave far better results than a single nozzle of the same throat area as the group of nozzles. The reason for this is to a large extent due to the fact that the alternate increasing and decreasing of the cross-sectional area of the steam stream is minimised by the contact of one steam stream with the next, when groups of nozzles are employed, and this helps considerably to increase the surface available for the entrainment of the air and gases. This entrainment is carried on mainly by friction, and it will be seen that if an appreciable amount of gas has to be dealt with, the frictional surface exposed to the gas has to be as large as possible. It is also inversely proportional to the density of the gas or fluid.

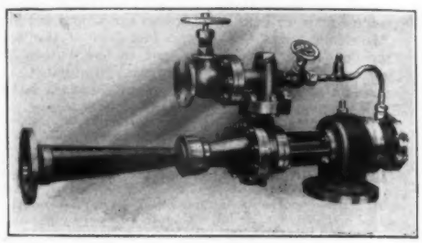
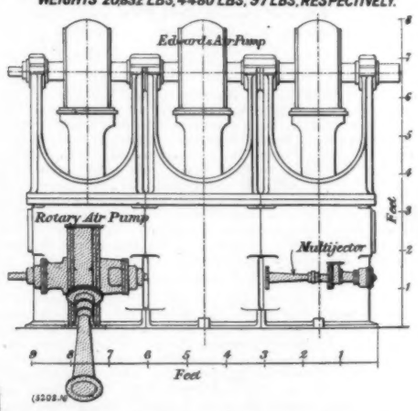


FIG. 12.

Fig. 13.

Fig. 14. RELATIVE SIZES OF EDWARDS, ROTARY & MULTIJECTOR AIR PUMPS FOR SAME STEAM DUTY. WEIGHTS 20832 LBS, 4480 LBS, 97 LBS, RESPECTIVELY.



The number and size of the nozzles depends entirely on the space available in the diffuser, and keeping within the limits of workshop practice. The smallest number employed by the Mirrlees Watson Company is three, each of which has a throat diameter of 1 mm. These are first-stage nozzles. On the largest size of pump, and in the second stage, the number of nozzles is 30, and these have a throat diameter of 5.2 mm. when using operating steam at 90 lb. per square inch.

Professor Leblanc, in his paper of 1911 to L'Association Technique Maritime, says that "the operating steam entrains the air by friction. During entrainment, it is the velocity of the steam which is utilised, and not its kinetic energy."

Calling M the weight of operating steam used per second, V its velocity at the outlet of the nozzles, m the weight of air drawn in per second, and W the velocity of the mixture of air and steam, then—

$$M V = (M + m) W$$

The ratio of the kinetic energy, $\frac{m W^2}{2}$, of the air drawn in to the kinetic energy, $\frac{M V^2}{2}$, contained in the operating

* Paper read at the Institution of Engineers and Shipbuilders in Scotland.

steam as it comes out of the nozzles can therefore be stated as

$$\frac{m\,W^2}{M\,V^2} = \frac{m\,M}{(M+m)^2}$$

so that when $\frac{m}{M}$ = 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$

$$\frac{m\,M}{(M+m)^2} = 0.25,\ 0.222,\ 0.187,\ 0.160,\ 0.139.$$

This shows that if the utilisation of the kinetic energy is to be the basis of the design, then for maximum efficiency it is necessary to bring the ratio $\frac{\text{air dealt with}}{\text{operating steam used}}$ as near to unity as possible.

M. Leblanc continues :—"We tried to diminish the loss of kinetic energy by producing at the entrance of the diffuser a higher vacuum than was necessary, so that the fluid drawn in came in contact with the operating steam with a considerable velocity. If the efficiency of the diffuser could be brought almost to unity, we could add considerably to the overall efficiency, but this has been found to be impracticable. Following on this,

Fig. 15. AIR DEALING CAPACITY OF VARIOUS MIRRLEES LEBLANC MULTIJECTORS.

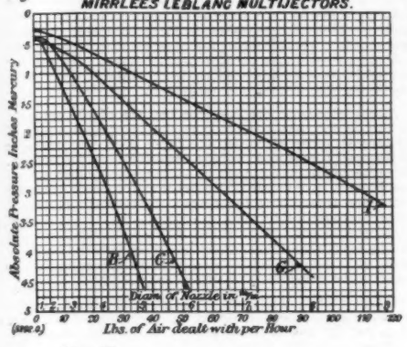
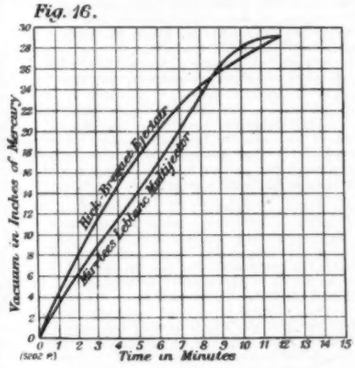


Fig. 16.



it was suggested to use puffs of steam after the manner of steam coming out of locomotive chimneys, but the complications involved in making arrangements for stopping the inlet of air during each puff were such that it would have been easier to use a centrifugal compressor. Afterwards we tried to compensate for the bad efficiency due to frictional entrainment by transforming heat into kinetic energy in the nozzles. Superheating the operating steam, although so useful for turbine work, is, however, not good for an ejector, because it is more difficult to effect compression in the diffuser, which outweighs the advantages obtained in the nozzles. The next scheme was to use hot water in the nozzles, but this also proved unsuccessful."

After numerous other trials it was decided that entrainment by friction was most economical, and various types of diffusers and different groupings of nozzles were experimented with, until the present ejector, as shown in Figs. 10, 11 and 12, was decided to be the most suited for condenser work. To go through the various stages in detail which led up to this design would take up too much time. With the form of ejector adopted it has been found that the efficiency of the nozzle is on an average 85 per cent., whilst that of the diffuser is 70 per cent. It will be seen that this ejector agrees very well with the ideal ejector which Professor Leblanc had in his mind. The first stage, which consists of a small group of nozzles, serves a triple purpose, inasmuch as it effects a certain amount of compression, heats up the entrained air, and gives it considerable velocity, and consequently an increase in momentum. The second stage has a larger number of nozzles, and it is here where the major portion of the work is done, the air being compressed from approximately 26 in. vacuum up to something more than atmospheric pressure. To be more accurate, the steam used in the first stage is about 5 per cent. of the total.

In support of the fourth advantage which this air pump is supposed to possess the following figures were obtained on the French torpedo-destroyer Boutefeu. The turbines were stopped, but steam was on the glands. The volume to be evacuated was about 635 cub. ft. After 1 minute the vacuum was 6$\frac{7}{16}$ in., 2 minutes 15 in., 3 minutes 22$\frac{1}{16}$ in., 4 minutes 25$\frac{5}{16}$ in., 5 minutes 26$\frac{1}{2}$ in., and 6 minutes 27$\frac{9}{16}$ in. The theoretical vacuum corresponding to the temperature of the water, 67.1 deg. F., viz., 28$\frac{1}{4}$ in., was attained in 11 minutes. It was also arranged later to allow certain known air leakages to enter the condenser. With a 5-mm. nozzle, which passes 36.2 lb. of free air per hour, the vacuum dropped only $\frac{1}{4}$ in. With a 15-mm. nozzle, which is equivalent to 326 lb. of air per hour, the vacuum was 21$\frac{1}{4}$ in. With an inch cock full open it took 11 minutes for the vacuum to fall to 12$\frac{1}{4}$ in., at which figure the mercury column remained steady. On closing the regulating valve below the nozzle, the vacuum at once rose and attained the maximum almost immediately. There is a central station near Glasgow where this type of apparatus is at work with a multijet condenser. Sometimes when changing machines there is liability partially to lose the water for a minute or so, but none of the staff ever have to trouble about the ejectors, and as soon as the water comes back again the vacuum at once builds up, and the set is never shut down through failure of the air pumps. As a matter of fact, in the case above stated, it is highly probable that during the period that the water supply to the condenser is very small there is an air passage between the water spaces of the other condensers in the station and the multijet plant which would allow of a very excessive quantity of air getting into the condenser on load. This also shows that stability, the sixth claim, is another salient point.

That high vacuum can be obtained is proved by the fact that this apparatus is now being used in the French Navy and mercantile marine, as well as on some land installations for refrigerating purposes, and installations are at work where the maximum vacuum obtained is within 1 mm. of the barometer. For condensers the best results yet obtained by the French Westinghouse Company are within 5 mm. of the barometer.

From the foregoing remarks it would appear that this type of air pump is ideal for use on board ship, and particularly in the Navy, where space is so valuable and weight of such consideration, and to illustrate this point Fig. 14 has been produced, and represents to the same scale an Edwards air pump, Leblanc rotary air pump, and Leblanc multijector for a steam duty on a surface condenser of 40,000 lb. per hour, water at 60 deg. F., vacuum 28$\frac{1}{2}$ in., and barometer 30 in. The weights are approximately 20,832 lb., 4,480 lb., and 97 lb., respectively. For land work it is equally suitable, and will soon supersede the rotary pump in many power stations. For sugar refineries, chemical, and other allied works it should prove exceptionally attractive, and take the place of many reciprocating dry air pumps.

It may be advisable to point out here that this pump is purely a dry air pump, so that for surface condensers an additional water or condensate pump is still required, and for jet plants the usual extraction pump.

Fig. 15 shows the air-dealing capacity of various sizes of multijector pumps taken from the actual tests. The maximum vacuum in each case is equivalent to the theoretical, the slight difference at the origin of the curves being due to the different test conditions.

The table of tests, II, is taken from a plant installed at the Scottish Central Power Station at Bonnybridge at a date six months after the plant was put on commercial load. This company has just decided to order another plant, and has specified Mirrlees-Leblanc multijector air pumps.

Fig. 16 shows the time taken to start up a Hick-Breguet *ejectair* and a Mirrlees-Leblanc multijector.

There is no doubt that considerable improvements have been effected in air-pump design during the last few years, nevertheless there is still room for further progress, and it is to be hoped that when the British engineer has time once again for research work we shall have to drop all our present-day notions of efficient air pumps for a type which will render all others obsolete.

Fig. 17.

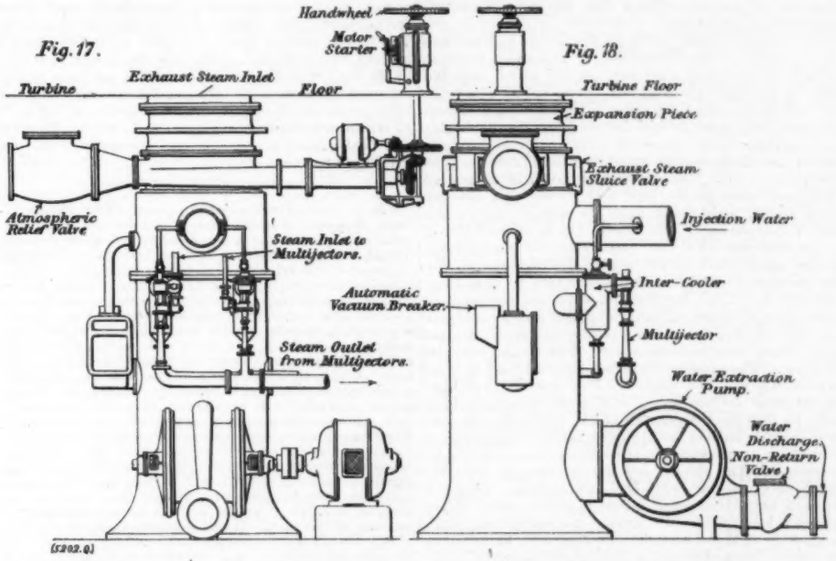


Fig. 18.

TABLE II.—OFFICIAL TEST OF NO. 18 M. J. CONDENSING PLANT WITH MOTOR-DRIVEN WATER-EXTRACTING PUMP, 1-SIZE "G" AND 1-SIZE "I" MULTIJECTOR AIR PUMP INSTALLED AT THE SCOTTISH CENTRAL ELECTRIC POWER COMPANY, LIMITED, BONNYBRIDGE. (Figs. 17 and 18.)

Duty—50,000 lb. steam per hour.
Vacuum—28.5 in. (barometer 30 in.).
Injection water—3,800 gallons per minute, temperature 65 deg. F.
Air pump capacity—84 lb. air per hour with guaranteed vacuum and water temperature.
Large ejector to operate condenser alone on loads over one-third and up to two-thirds full load.
Small ejector to work alone on loads of one-third full load and under.
Both ejectors to work on loads over two-thirds full load.

Time.	Load.				Vacuum.		Barometer.	Steam Press. on Ejectors.		Steam Press. on Turbine	Injection Water.		Extraction Pump.			
	Volts.	Amps.	P.F.	Kw.	Turbo.	Condr.		"G."	"I."		Inlet.	Outlet.	Press. Gauge.	Amps.	Volts.	R.P.M.
8.45 p.m.	6,350	130	0.75	1,070	28.1	28.2	29.8	120	Shut off.	152	—	—	5	58/60	440	480
11.0 a.m.	6,350	266	0.7	2,000	28.5	28.5	29.66	122	130	152	43	70.0	4	60	440	480
12.0 a.m.	6,350	280	0.7	2,152	28.6	28.5	29.63	122	125	152	43	70.0	4½	59	440	480
12.5 a.m.	6,400	270	0.7	2,090	—	28.2	29.63	Shut	125	152	43	70.0	4½	59	440	480
2.15 p.m.	6,400	325	0.75	2,700	28.2	28.25	29.59	125	160	150	43	72.5	5	62½	440	480
2.45 p.m.	6,450	345	0.76	2,970	28.2	28.3	29.59	125	157	157	43	72.5	5	62½	440	480
3.0 p.m.	6,500	280	0.74	2,330	28.2	28.4	29.6	122½	160	153	43	65.5	4	62½	440	480
3.30 p.m.	6,500	230	0.7	1,182	28.5	28.5	29.6	120	150	154	43	65.5	2	53	440	480

FLOATING STEAM CRANES.

We illustrate on page 282 two floating steam cranes constructed by Sir William Arrol and Co., Limited, of Glasgow, Fig. 1 being a self-propelled 30-ton crane for Rio de Janeiro, Brazil, and Fig. 2 a non-propelled 50-ton crane for Quebec. Generally the construction is the same, the differences being due to the load.

The 30-ton crane has a maximum outreach from the side of the pontoon of 10 m. (32 ft. 9.7 in.) and a minimum radius of 9 m. (29 ft. 6.3 in.). The height of the lift above the water-line is 25 m. (82 ft. 0.2 in.), and the range of lift below the water-line 8 m. (26 ft. 3 in.). The pontoon, which was constructed to comply with Lloyd's 100 A 1 class, by Messrs. Ritchie, Graham and Milne, of Whiteinch, Glasgow, is 150 ft. long by 50 ft. beam and 8 ft. deep, and is divided into six watertight compartments, the deck and hull being, of course, specially stiffened to stand the stresses caused by the crane and load. The propelling engines are of the compound surface-condensing type, the cylinders being 13 in. and 26 in. in diameter, adapted to a stroke of 18 in., while the boilers, supplying steam at 100 lb. pressure, are of the water-tube type, and the designed speed is 7 knots. Accommodation is provided for officers and crew, and a complete set of diving apparatus for two divers is carried. The pontoon, of course, is fitted with the usual deck and navigating appliances.

The general construction of the crane will be seen by reference to the illustrations. The superstructure is built up of rolled steel sections and plates, and the base is arranged to carry the crane engines and the driver's house, with all gearing. The whole is mounted on eight cast-steel rollers carried in pairs by bogies in order to divide the load equally on the rollers, which are bushed with gun-metal and mounted on fixed steel pins. The roller path consists of a steel billet machined on the face, and riveted to a circular steel girder, with fixing bolts for attachment to the top of the pontoon. The centre pin is of steel, fitted in bearings carried by the superstructure and pontoon girders respectively. The centre pin is arranged for the passage of live and exhaust steam to and from the engines. The crane engines, which are independent of the propelling set, although supplied with steam from the same boiler, are of the double-cylinder, horizontal type, the cylinders having a bore of 10 in. and a stroke of 12 in. The speed of hoisting the full load is 6 m. (19 ft. 8.2 in.) per minute. The hoisting winch is of the double-drum type, each drum being provided with an independent snatch-block, consisting of cast-iron pulleys bushed with gun-metal, and mounted on a steel pin, connected by steel links to a forged steel crosshead. The drums are driven through two reductions of machine-cut steel spur gearing, arranged so that both drums are driven together when lifting the full load, while one drum may be driven independently of the other when dealing with loads up to 15 tons. The drums are of sufficient diameter to take the full length of rope at a single lap. Each winch is fitted with a powerful band brake, applied from the operator's cabin, and capable of sustaining the full load. A claw clutch is fitted to couple the hoisting gear up to the engine. The slewing is effected at the rate of one revolution in three minutes, by means of a pinion carried on the end of a vertical shaft, supported by massive bearings on the superstructure, gearing into the pin rack on the outside of the roller path. The upper end of this vertical shaft is driven by the engines through spur and bevel gearing. Double cone clutches are fitted, in order that the crane may be slewed in either direction without reversing the engines. The jib of the crane may be derricked from the maximum to the minimum radius in 5 minutes. This is done by means of two forged steel screws, with a special form of thread, made to revolve in two phosphor-bronze bushed nuts, provided with trunnions and carried at the end of the jib ties. The screws are driven through spur and bevel gearing, and a claw clutch is fitted to couple up the gear to the engines. Ball thrust bearings are fitted at the end of the screws to reduce the frictional losses. The jib is held in any position by a band brake. The necessary ballast for the stability of the crane is carried in a special tank at the tail of the superstructure. Two Dennison suspended weighing machines are supplied with the crane, one designed for loads up to 35 tons and the other for loads up to 10 tons. At the bow of the vessel there is fitted a 5-ton independent jib crane, having an outreach of 2 m. (6 ft. 6.7 in.) over the side of the vessel, and a range of lift of 30 m. (98 ft. 5.1 in.) below the water-line. It may be added that the vessel sailed to Rio de Janeiro under its own steam.

The 50-ton crane has a maximum radius of 60 ft. and a minimum radius of 35 ft. The range of lift above the water-line is 62 ft., and the total range of lift 102 ft. The hoisting and derricking engines have 10-in. cylinders and 12-in. stroke, the steam pressure being 100 lb. Steam is generated in a return-tube, marine-type boiler, 7 ft. 6 in. in diameter by 8 ft. 6 in. long. The furnace is 3 ft. 3 in. in diameter, and there are seventy-four 3-in. tubes. Two hoisting speeds are arranged for, the slow gear lifting the full load (50 tons) at 10 ft. per minute, and the quick gear raising a 10-ton load at 50 ft. per minute. The load is lifted on eight parts steel wire rope, winding two parts on to the cast-iron drum driven by the steam engine through three reductions of steel spur gearing. The two sets of gearing have different ratios for the first reduction, in order that the two specified speeds of hoisting may be obtained. The jib, when carrying the 50-ton load, is derricked from the maximum to the minimum radius in 7 minutes. In this crane there is only one derricking screw, instead of two, as in the smaller crane, the phosphor-bronze bush nut being mounted on an equalising beam and carried at the end of the jib ties. The slewing is effected as in the other crane, but at a speed of one revolution in 2 minutes. In order to keep the angle of heel of the pontoon small—when the crane is at its maximum radius it is not more than 5 deg.—the crane is provided with travelling ballast, mounted on two carriages, arranged to run on the outside longitudinal girders of the superstructure. The ballast is traversed along the girders by means of flat link-chains connected to each end of the carriage, and running over sprockets driven by a special slewing engine, having cylinders 7 in. in diameter and 10-in. stroke, working through suitable reductions of gearing. The ballast-racking gear is coupled up to the slewing engines by a suitable clutch, and the ballast is racked at the rate of 50 ft. per minute. The pontoon in this case was also built by Messrs. Ritchie, Graham and Milne, and has a length of 132 ft., with a beam of 42 ft., the scantlings being equal to Lloyd's. There is a 3 brake horse-power electric generating set for lighting purposes.

Ferro-Concrete Floating Dock.—The Frederikshavn Shipyard and Floating Dock, Jutland, Denmark, is at present building a ferro-concrete floating dock on a field facing the sea. It is being built on a foundation of boards, 100 ft. long and 69 ft. broad, on which is mounted a skeleton of 340 iron pillars, connected at the top with girders. The reinforcement of the bottom consists of a network of rods and wires. The concrete is poured in wooden moulds round the pillars; the outer and inner walls of the dock will be 4 metres thick, and the bottom will have the same dimensions. The sides of the dock are divided into six compartments, which can be filled with water by opening the bottom valves, and they can be emptied by power installations in a small compartment in each of the six water tanks. The floating dock, when completed, will weigh some 700 tons; the work, as in so many other cases, has been retarded through shortness of raw materials, and it can hardly be launched till the end of the year. The launch will take place at high water straight from the field into the sea, and the structure will afterwards be towed to its place at the yard. It will be used both for the building of new vessels and for repairs, and can be connected with the present dock, so that for the future larger vessels can be repaired at the yard.

German War Profits.—The Hoesch Iron and Steel Works, Dortmund, are able to show an exceptionally good balance sheet for the year ended June 30, 1917, their manufacture of steel products more especially having profited by the war. The company has now again been able to declare a dividend of 24 per cent., as in 1912–13, the intermediate dividends having been 18, 12 and 20 per cent., in which connection it should be remembered that the share capital was raised from 20,000,000 marks to 28,000,000 marks shortly before the war broke out. The returns of last year, however, far exceed those of any previous year, the gross profits being 27,588,018 marks, against 13,601,002 marks for the preceding year, 5,459,934 marks for 1914-15, and 13,102,639 marks for 1912–13, the net profits for the four years being respectively 17,344,334 marks, 8,841,296 marks, 1,085,544 marks and 7,399,205 marks. The exceptional profits of the last financial year have allowed of extraordinary writings-off amounting to 6,028,755 marks, in addition to ordinary writings-off of 4,214,930 marks, about the same as last year, when the extraordinary writings-off only amounted to 550,000 marks. A sum of 2,500,000 marks was reserved for pension and workmen's fund, against 650,000 marks the previous year; 1,000,000 marks were added to the national institution, against 150,000 marks last year; 2,000,000 marks were reserved for alterations following the conclusion of peace, against 1,000,000 marks for the preceding year; 3,000,000 marks were reserved for war profit taxation, against none in previous years; and 1,000,000 marks, as in the previous year—and then for the first time—were reserved for mining accidents. The Hohenlohe works have also, in gross profits, exceeded the figures of 1912–13 and approached those of 1911–12, but owing to increased writings-off—7,487,000 marks against 4,525,000 marks for 1912–13—the net profits only come out at 4,849,000 marks, or about the same as last year, against 6,558,000 marks for 1912–13. For this latter year a dividend of 8 per cent. was declared, no dividend was paid for the two following years, and 6 per cent. for last year and the last year but one. It should be remembered that the Hohenlohe concern has no iron works, but only zinc and coal mines.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—The position of the steel trade in the West of Scotland remains practically unchanged, the maximum output being obtained in every instance, despite the difficulties connected with the scarcity of raw material. War requirements continue to dominate the situation, although, when urgently wanted for work of special importance, permission may be granted for the production of small lots of finished or semi-finished material. Other than this, little is available for the purposes of ordinary mercantile business, while it is impossible to accumulate any stock whatever. Shipbuilding material is in such heavy demand that local steel makers have difficulty in supplying all that is required for the construction of the increased tonnage aimed at by the Shipping Controller. Shipments overseas are steadily vanishing, and these only to allied countries. Except where officially fixed, stiff prices are the rule meantime.

Malleable Iron Trade.—So great is the home demand for malleable iron that, even were permits for shipment procurable, it is problematical if there would be any quantity to spare for export. Every ton produced goes direct to the consumer, invariably pressing for immediate delivery. So far, no definite arrangements have been made for allocating supplies for the purposes of ordinary mercantile trade, either at home or abroad, Government contracts swallowing up the entire output. At 16*l.* per ton and upwards f.o.b. Glasgow, "Crown" bars have touched a level the highest on record.

Scotch Pig-Iron Trade.—The feature of the moment in the Scotch pig-iron trade is the growing scarcity of all brands, quite alarming at a time when everything is so urgently required in the interests of the nation. Even hematite, which goes in large quantity direct from the furnace to the steel works, is not now so plentiful as it was some little time ago. Makers are finding it almost impossible to maintain the output at the desired level, and in consequence iron and steel scrap is greatly in request. Government requirements are still the most important form of business, and private trading has to stand aside completely. Prices remain firm.

Glasgow and Munitions Appointment.—Another prominent Glasgow business man, in the person of Mr. John Mann, C.A., has been chosen to occupy an important position under the Ministry of Munitions. In the recent rearrangement of the functions of the Finance and Contracts Departments Mr. Mann has been appointed Controller of Munitions Contracts, a post which he is singularly fitted to occupy. Since 1915, when he first undertook duty under Government, Mr. Mann has been intimately connected with the Ministry of Munitions, having served on several important committees and given much valuable assistance to his co-workers. Outside of business, in his native city, he has always taken a keen interest in social, philanthropic and educational movements, so that he is in every way peculiarly suited for administrative work.

Clyde Trust Prosperity.—It is interesting to record that, despite numerous untoward happenings connected with German submarine warfare, the Clyde Trust at its annual meeting a few days ago made known the fact that the year ended June 30 showed a state of prosperity which is particularly gratifying and, in a way, almost unexpected. Only once in its history has there been a larger surplus than that just intimated—31,373*l.* On this occasion the Clyde stands out prominently, as many other seaports, not so favourably situated from a geographical point of view, have suffered severely. All over, the figures tell a tale of astuteness and business acumen which redounds to the credit of the chairman, Sir Thomas Mason, and those associated with him in the direction of the affairs of the Trust.

Glasgow Shipping.—There has just been published from the *Journal of Commerce* offices, 93, Hope-street, Glasgow, the "Glasgow Shipping Who's Who," at the price of 1*s.*, or by post 1*s.* 3*d.* This publication gives, in alphabetical order, particulars of the shipowning lines and of the shipbuilders on the Clyde, including a note regarding the capital of the public companies, a list of directors and officials, and particulars relating to the capacity and output of the yards which each builder owns. There is also a list of shipbrokers, details of harbour and dock accommodation, and personal data regarding the transport, marine insurance, technical, and other organisations associated with the shipping of the Clyde.

American Shipbuilding.—The three Hannevig shipyards are located at Delaware, which is now one of the largest shipbuilding centres in the world. The three yards are to be managed as one concern. One ship will be ready in November, and after that at least one ship will be ready every month. The yards are designed to employ some 5,000 hands, and the capital will be increased. The plans comprise the building of a dry dock for vessels up to 20,000 tons. At present the Pusey and Jones yard employs 1,100 hands and the Pennsylvania yard 1,000 hands. The extension of the former yard has so far entailed an expenditure of 750,000 dols., but another 250,000 dols. will be needed before the alterations are completed. At present these two yards have orders amounting to 200,000 tons, including 10 vessels of 4,000 tons each at the Pusey and Jones yard, and 28 vessels, of from 7,000 to 13,000 tons, at the Pennsylvania yard. The latter yard recently secured an order for six steel tank steamers of 7,000 tons d.w. each.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Firmness continues to characterise Cleveland pig-iron, but home transactions are not numerous or extensive, as consumers generally have completed this month's purchases. In addition to this month's very substantial sales of foundry iron to customers north of the Tweed, considerable contracts for delivery of forge quality to Scotland over the next three months are stated to have been made. The demand from abroad keeps keen, and export trade is only limited by licences. Most of the iron shipped is still going to France through official channels, but Italy is now receiving fair quantities, and one or two licences for export to Japan are reported to have been granted. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; and for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores still stands at 1,137 tons, all of which is No. 3 quality, no change having been recorded since July 7 last.

Hematite Iron.—Continued strict official control of distribution enables home consumers to obtain sufficient supplies for their legitimate needs, and leaves some small surplus available for sale abroad. A few negotiations are reported for the fixing up of further home contracts. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use and 141*s.* f.o.b. for shipment to France and Italy, but the export quotation is subject to extra charges in the way of excess ore freights charged by neutrals above the parity, as well as other certain expenses.

Coke.—All descriptions of coke are in good demand, and a rather pronounced tendency to buy forward for export is noticeable. "Beehive and best foundry kinds remain at 42*s.* 6*d.* for shipment, and gas-house product is in the neighbourhood of 30*s.* Local consumption is heavy, and values of blast-furnace qualities are well maintained at fixed maximum rates, average kinds realising 28*s.* at the ovens, and low phosphorus sorts selling at 30*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—With the capacity of finished iron and steel works almost entirely absorbed by heavy Government requirements and the very large and still-increasing demands of the shipyards, manufacturers are indifferent to ordinary commercial inquiries. Every effort is put forward to expedite output of steel for the shipyards. Strict control of exports continues, the permits obtainable being only for limited quantities of certain descriptions for the Allies and the Dominions. Prices all round are very strong, and packing iron and steel have been advanced 10*s.* per ton. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

MOLYBDENUM.—In the United States Bureau of Mines Bulletin 111, entitled "Molybdenum; its Ores and Concentration," by F. W. Horton, there is a selected bibliography in which references are given to about eighty publications dealing with molybdenum in various aspects. The bulletin is issued by the Government Printing Office at Washington at the price of 30 cents.

OPTICAL PROPERTIES OF CARBORUNDUM.—Last year the University Museum of Göttingen was presented with some fine crystals of carborundum from the carborundum works at Schachen, near the Lake of Constance. An investigation of the properties—thermal, electric and optical—of these crystals was published by Dr. O. Weigel in "Gesellschaft für Wissenschaften," of Göttingen; this publication is not available at present, an abstract of the researches on the optical properties is, however, given by H. Krüss in the *Zeitschrift für Instrumentenkunde* of July, 1917. There were two fairly colourless, clear prisms, of dimensions of several millimetres, with an edge length of 0.5 mm., and one rather black crystal, which was sufficiently translucent, however, for the examination by means of a quartz-mercury beam or an electric carbon arc. Even the clear crystals were not free from black enclosures, probably of iron carbide. The interesting point is that the refractive index was determined at temperatures up to 1,140 deg. C., and the absorption even at 1,700 deg. and 1,800 deg. C. In the first set of observations the wave-length of the incident light varied from 435 $\mu\mu$ up to 705 $\mu\mu$; at higher temperature, however, the refractive index increased more rapidly in the violet than in the red, and the ultra-violet absorption band was shifted towards the red. The refractive index was found to agree with the formula of Kettler-Helmholtz; the refractive indices (sodium light) for the ordinary and extraordinary rays were 2.648 and 2.694. Weigel gives the temperature coefficients for refraction and absorption; Krüss doubts, however, that the high-temperature observations (made in an electric furnace) were sufficiently reliable, considering that both the crystal and the metal of the apparatus would be affected by the high temperatures. The colourless crystals turned a deep green-yellow at red heat.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—With the new scheme coming into operation this week considerable attention has been given to the question of arranging supplies, but little in the way of definite understandings has been arrived at. Merchants complain that only one-tenth of the promised alternative supply is available, and that with the cutting off of the tonnage which came from the Nottinghamshire and Derbyshire collieries there is bound to be a general shortage, especially as the reserves at the pits are only of a very small character. Another source of complaint is that in many cas the alternative tonnage is either of a superior or an inferior quality to that which was being obtained outside this specific area. This has led to increased difficulties, and the outcome is further to perturb both the consumers and the purveyors. Representations have been made to the Coal Controller on this point, and also on the question of house fuel. It is authoritatively stated that more house coal is being sent to London than has ever been known before in recent times from Yorkshire collieries, and the result is to place the Yorkshire dealers at a grave disadvantage in making arrangements for the coming winter. The local Corporation has taken the matter up with the authorities in London. The general position is one of unexampled tightness, with works anxious to get all in the shape of reserves that they can. Not a great deal of success attends their efforts, for there is comparatively small tonnage passing for open market sales, and contract accounts are barely fulfilled. Quotations: Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—Satisfactory results attend the efforts that are being made to increase the output of steel, and plant and men are now again working top pressure in a manner reminiscent of the smooth running which was a prelude to the holiday interruption. All steel plant, no matter for what particular purpose the material is required, is working at the top of its capacity. Marine work shows no signs of diminishing whilst aeroplane work has increased, thanks to the completion of several new electric furnaces which are specially adapted to the production of alloyed steels. Crankshafts for aeroplanes are being made of special alloyed steel, the quality of which must be of the finest. Cylinders and connecting rods for the same machines are also required in large numbers, and the quality here has to be second to none. Aeroplane stampings and bar steel of special alloys are included in further details of the complexity of orders which the increased air activity has brought Sheffield way. A high authority who inspected many of the works under actual working conditions a few days ago expressed the satisfaction of the air authorities at what is being done here, and laid great stress upon both the capacity for output and the uniformly good quality which was obtained. Tank construction and repair work is also making heavy calls upon steel makers, whilst with the expansion of the tool trade to such an unprecedented extent there is a brisk demand for both carbon and high-speed tool steels, with orders for the latter brand on a figure not previously reached in the war. New shops are being fitted out to meet the needs, and machinery of a special character installed. Additional testimony has come forward of the high esteem with which overseas customers, especially those in Canada, regard the best Sheffield brands of high-speed steel. Saw and file makers are again working overtime, but to-day there is not such an overwhelming proportion of the output booked for Russia. Many of the firms here are anxiously awaiting the clearing of the cloud on the Russian horizon, for big business interests are at stake. The metal market shares the buoyancy of the other departments. All classes of raw material are sought after, and there has been heavy buying of both Lincolnshire and Derbyshire pig-iron. Forge and foundry brands are not so plentiful, but the tonnage of basic quality is better than for some time past. Derbyshire makers, having converted their forge and foundry furnaces to basic at the request of the Ministry of Munitions, are now receiving 97*s.* 6*d.* per ton, as against the maximum of 92*s.* 6*d.* for foundry. The change may not be an unmixed blessing for them, inasmuch as they have been compelled to sever substantial connections with the iron trade.

Sheffield Matters.—Great interest is being taken in the air exhibition at present being held in Sheffield on behalf of Lady Drogheda's fund for wounded and crippled airmen, and the announcement that the prominent business men of the city have subscribed 2,000*l.* to present an aeroplane to Britain's oldest colony of Newfoundland has given general satisfaction. The presentation will take place on September 29, when Lord Derby is expected to hand it over to Mr. Walter Long, who has undertaken to receive it on behalf of the colony.

JAPANESE SHIPBUILDING.—The Yokohama Dock Company (says *The London and China Telegraph*), which has started shipbuilding work besides repairing, has announced that it will shortly increase its capital from 3,700,000 yen to 10,000,000 yen. The company has been making wonderful progress during the past few weeks, and at the end of the par a dividend of 60 per cent. will be declared.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The market conditions continue very much the same as last week. In regard to home supplies the new coal transport reorganisation scheme is now in operation, and is occupying much of the attention of salesmen. As a matter of convenience, while the scheme is in its experimental stage, the majority of firms have asked their new purchasers for cash with order. In the meantime there is a keen demand for coals for home consumption. Coke is quite firm, and is in good demand. Pitwood is rather scarce this week, the supplies being about 10,000 tons less than last month, and it commands about 60*s.* to 61*s.*

Newport.—Quiet conditions continue to prevail, but stoppages of collieries in the Monmouthshire Valleys have not been frequent. The most embarrassing problem is that of small coal, of which there is such an excessive supply. There is a brisk business in household descriptions, but throughs and nuts are quiet.

South Wales Coal Trimmers' Demands.—The coal trimmers in the Bristol Channel ports are applying for a further advance of 37½ per cent. They have already had an advance of 37½ per cent., so that they are now applying for an aggregate war bonus of 75 per cent. The application is, of course, based on the increased cost of living, coupled with greater irregularity of work, which results in diminished earnings. The employers, in view of the present condition of affairs, suggest that the issue should be referred to the Committee on Production. No definite decision, however, was come to at the meeting of the Trimming Board held at the Cardiff Chamber of Commerce conference hall on Tuesday, and further negotiations were deferred until next Monday.

Colliery Officials' Strike Threat.—The lower-grade colliery officials who are members of the South Wales and Monmouthshire Colliery Examiners' Association have acted upon the instruction of the executive committee of that organisation, and have tendered a month's notice to terminate contracts. So far nothing has been done to avert the notices being acted upon, but it is not anticipated at present that matters will be allowed to reach a crisis. It is, nevertheless, difficult to predict with certainty what may be the upshot.

SHIPBUILDING EXTENSION IN DENMARK.—It is proposed to extend the Elsinore Iron Shipbuilding Company very materially. Both the town and the harbour authorities are willing to part with land for the purpose, and a portion of the Kronborg fortification, both ramparts and moat, will also be added to the company's site. This will enable the yard to construct a large floating dock, where Atlantic liners of up to 10,000 tons can be built. The majority of the share capital in the Elsinore Iron Shipbuilding Company is held by the Burmeister and Wain Shipyard and the United Steamship Company, both of which concerns are represented on the board.

OXIDATION OF COAL.—Experimenting with 14 samples of French coal, Georges Charpy and Marcel Godchot (*Comptes Rendus*, vol. 163, pages 745 to 747) observed that the coal heated to 100 deg. C. for 3 hours lost all its moisture, and that this loss of weight, amounting to 4 per cent. or 5 per cent., was practically identical with the loss which the coal showed in the desiccator in a vacuum. When heated up to 150 deg. C. the same loss was observed at a more rapid rate. When the heating to 100 deg. C. was prolonged, the weight increased by from 3 per cent. to 5 per cent., owing to the absorption of oxygen; heating to 100 deg. for three months gave an increase of 4 per cent. in one instance. Above 150 deg. C. there was again a loss of weight because CO_2 was liberated. At the same time a diminution in the calorific value of the coal was observed, whilst the percentage of ashes and the percentage of volatile constituents were hardly influenced; the loss of calorific power amounted to 13 per cent. in some cases. The chief point of the experimenters is that the customary analysis for ashes and volatile constituents would not reveal a loss in calorific power which might be quite substantial, and they are no doubt right in this. Chemists would hardly heat a coal above 105 deg. C., however, to expel the moisture, as the oxidation by the coal becomes appreciable already at relatively low temperatures.

NITROLIM.—In a recent lecture on the manufacture of cyanamide and kalkstickstoff (nitrolim), delivered in May last at Vienna, M. Dolch had remarked that the Swedish process of making the cyanamide in vertical shaft furnaces was not profitable, because the electrode consumption was high, and the nitrogen percentage of the final product rather low. Mr. F. Carlson, of the Aktiebolaget Nitrogenium, Ljungaverk, replies to this remark in a recent number of the *Chemiker Zeitung*, refuting the statement and giving some interesting particulars. The carbon electrodes, he says, are Plania or Höganäs electrodes, 350 mm. in diameter, which is not at all an exceptional size, since carbon electrodes are made in diameters of 1 m. There is no loss of pieces of the electrodes, which are constantly being lengthened. The electrode consumption is 3.75 kg. to 5.5 kg. per ton of kalkstickstoff, which is supplied in a porous ground mass containing 19 per cent. or 20 per cent. of nitrogen. The product is said to be very uniform just because the carbide gradually descends in the shaft furnace; 725 kg. of carbide yield 1 ton of kalkstickstoff. The furnace process is continuous, and it does not take so long as with other furnaces to start operations again after some breakdown in the power-house. In short, the process is described as both reliable and economical.

FLOATING CRANES.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 280.)

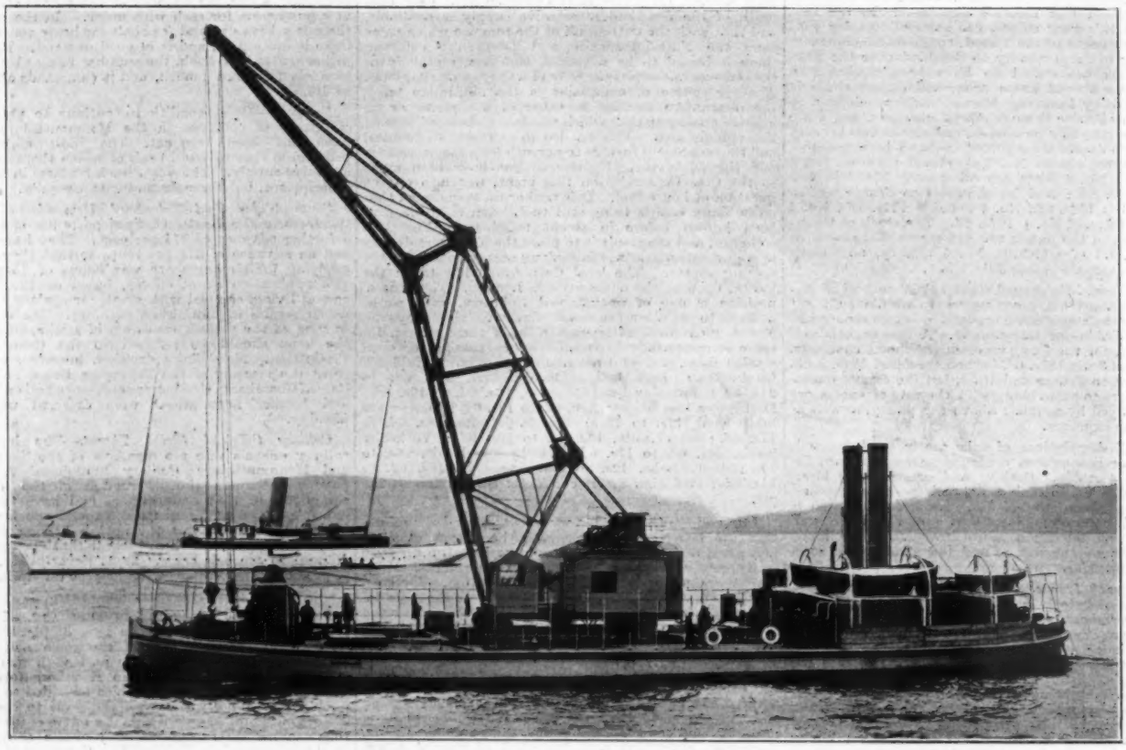


FIG. 1. SELF-PROPELLED 30-TON CRANE FOR RIO DE JANEIRO, BRAZIL.

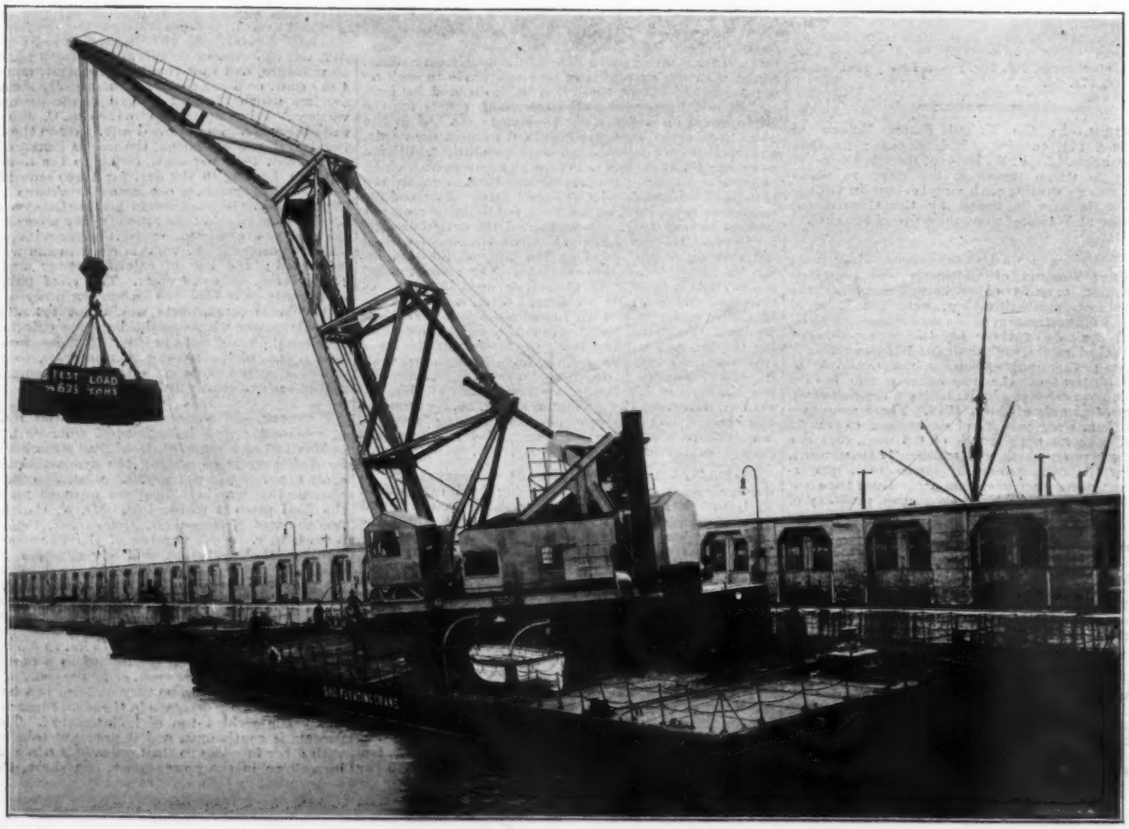


FIG. 2. 50-TON CRANE FOR CANADA

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page* 274.)

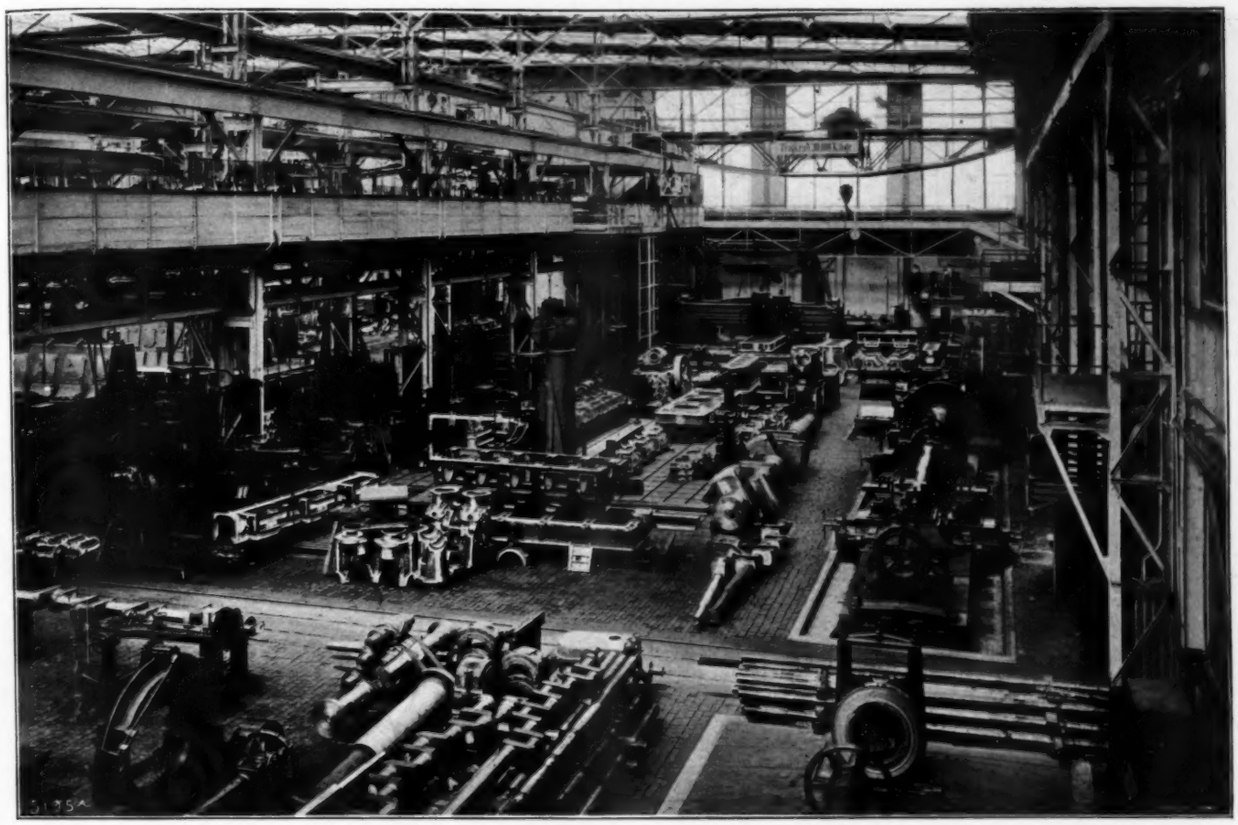


FIG. 164. VIEW IN THE MACHINE SHOP OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

FIG. 165. VIEW IN THE ERECTING SHOP OF MESSRS. SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*To face page* 274.)

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page 274.*)

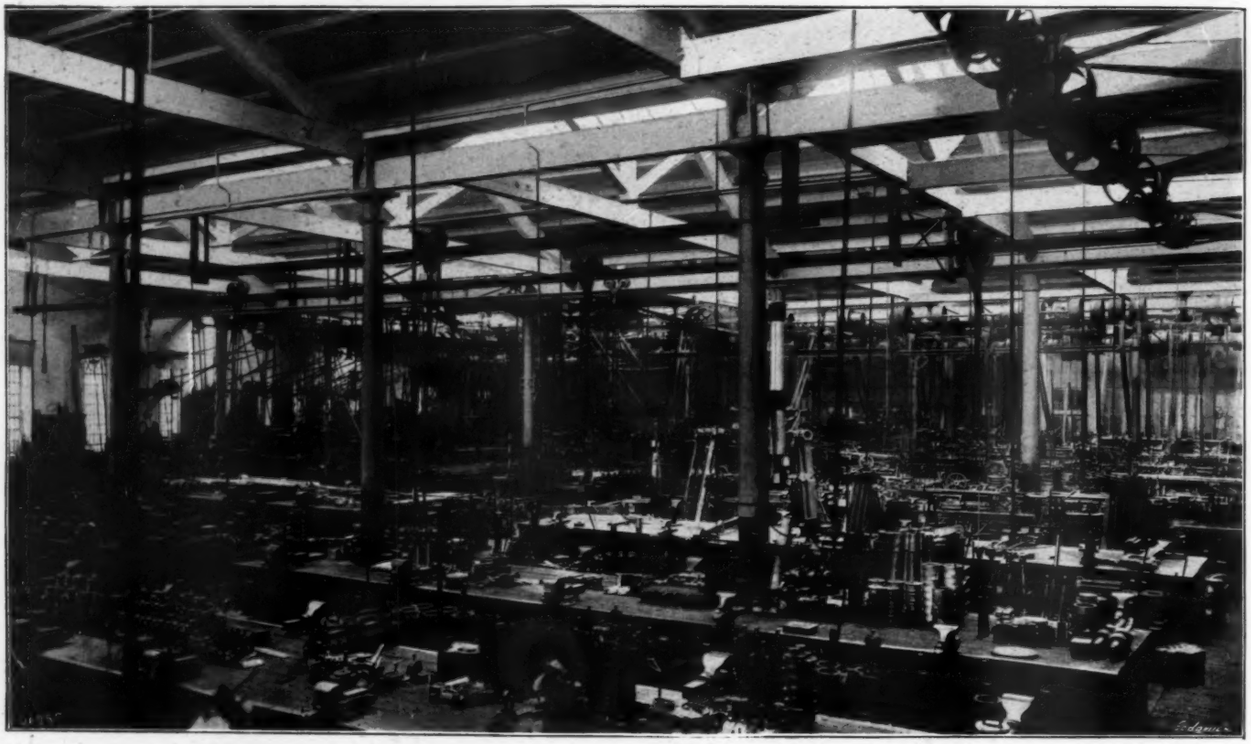


FIG. 166. FITTING AND MACHINE SHOP, LONDON AND NORTH-WESTERN RAILWAY WORKS, CREWE. MR. C. J. BOWEN COOKE, CHIEF MECHANICAL ENGINEER.

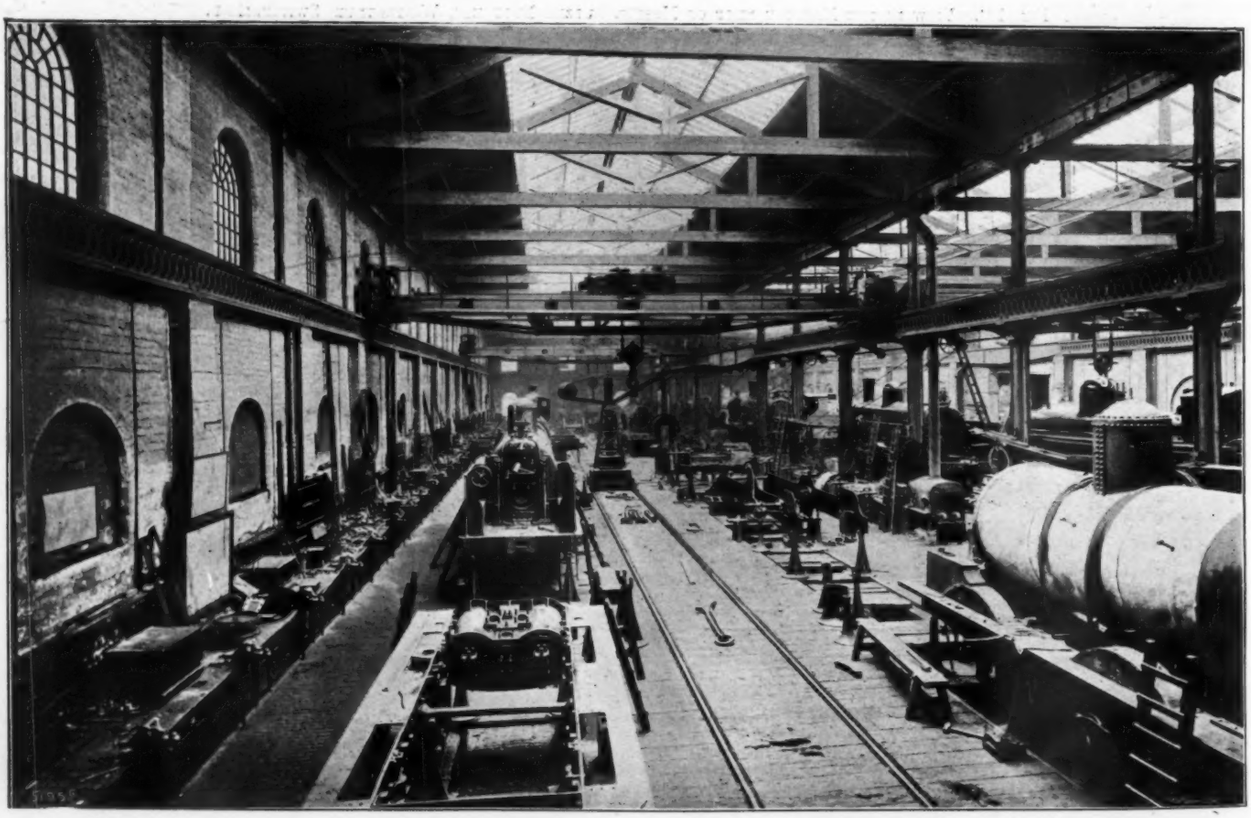


FIG. 167. LOCOMOTIVE ERECTING SHOP, LONDON AND NORTH-WESTERN RAILWAY WORKS, CREWE. MR. C. J. BOWEN COOKE, CHIEF MECHANICAL ENGINEER.

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page 274.*)

Fig. 169. View in Turnery of the Hendey Machine Company, Torrington, Conn., U.S.A.

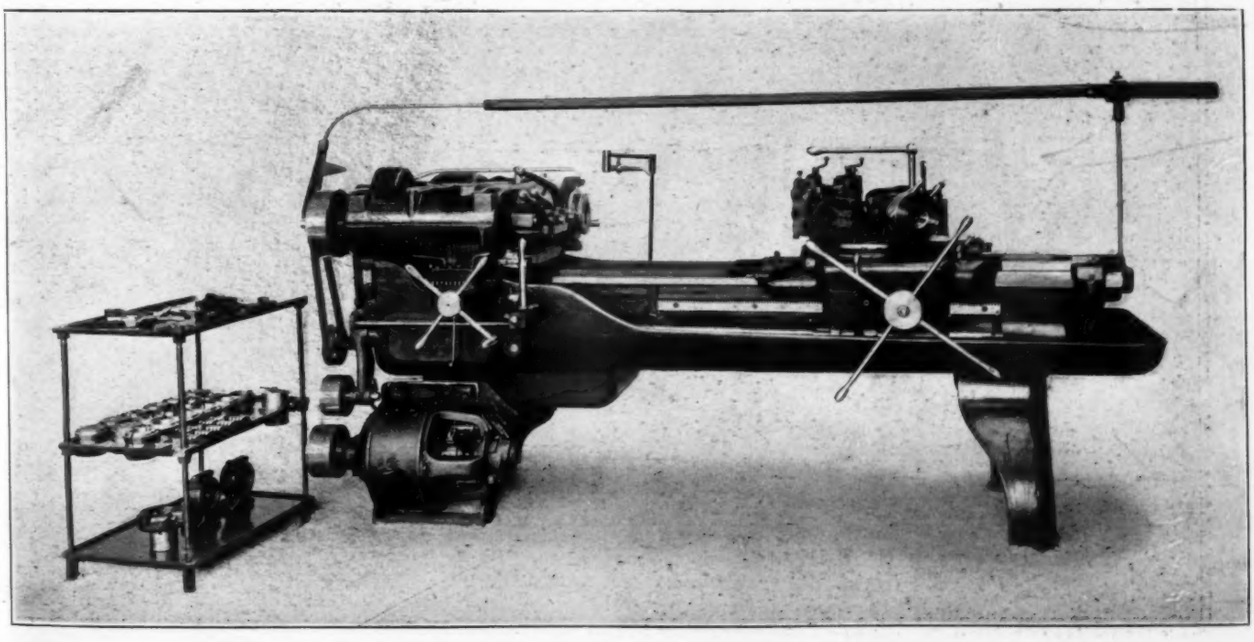


Fig. 170. Acme Flat Turret Lathe, with Stand for Accessories. The Acme Machine Tool Company, Cincinnati, Ohio, U.S.A.

THE ARRANGEMENT OF MACHINE SHOPS.

(*For Description, see Page 274.*)

FIG. 171. VIEW IN THE BURNAGE WORKS OF MESSRS. HANS RENOLD, LIMITED, DIDSBURY, MANCHESTER.

FIG. 172. SHOP WITH AUTOMATIC LATHES AT THE BURNAGE WORKS OF MESSRS. HANS RENOLD, LIMITED, DIDSBURY, MANCHESTER.

(*To face page 275.*)

AGENTS FOR "ENGINEERING."

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With Four One-Page Plates of the ARRANGEMENT OF MACHINE SHOPS.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS.—Wednesday, September 19, in the Rooms of the Chemical Society, Burlington House, Piccadilly, W. 1. At the opening session, between the hours of 4 p.m. and 6.30 p.m., the following communications will be presented:—(1) "Experiments on the Fatigue of Brasses," by Mr. B. Parker Haigh, D.Sc. (London); (2) "Hardness and Hardening," by Professor T. Turner, M.Sc., A.R.S.M. (Birmingham); (3) "The Effects of Heat at various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet," by Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M. (London), and Mr. L. Taverner, A.R.S.M. (London); (4) Note on "A Comparison Screen for Brass," by Mr. O. W. Ellis, M.Sc. (London). At the evening session, from 8 p.m. to 10 p.m., the programme will be as follows:—(5) "Further Notes on a High-Temperature Thermostat," by Mr. J. L. Haughton, M.Sc. (Teddington), and Mr. D. Hanson, M.Sc. (Teddington); (6) "Principles and Methods of a New System of Gas-Firing," by Mr. A. C. Ionides (London); (7) "Fuel Economy Possibilities in Brass-Melting Furnaces," by Mr. L. C. Harvey (London); "The Effect of Great Hydrostatic Pressure on the Physical Properties of Metals," by Professor Zay Jeffries, B.Sc. (Cleveland, U.S.A.); (9) Note on "The Use of Chromic Acid and Hydrogen Peroxide as an Etching Agent," by Mr. S. W. Miller (Rochester, N.Y., U.S.A.). In connection with Mr. Ionides' paper a demonstration of a new system of furnace heating will be given.

THE IRON AND STEEL INSTITUTE.—Thursday, September 20, at 10.30 a.m., at the Institution of Civil Engineers, Great George-Street, Westminster. General meeting of members. Scrutineers will be appointed for the examination of voting papers for the election of new members of the Institute. A selection of papers will be read and discussed (Nos. 1, 4, 5, 9 and 2). Friday, September 21, at 10 a.m. General meeting of members. A selection of papers will be read and discussed (Nos. 10, 6, 7, 3 and 8). The following is the list of papers that are expected to be submitted for reading and discussion:—(1) "Present Practice in Briquetting of Iron Ores," by Mr. G. Barrett and Mr. T. B. Rogerson; (2) "Microstructure of Commercially Pure Iron between Ar_3 and Ar_2," by Mr. W. J. Brooke and Mr. F. F. Hunting; (3) "The Influence of Heat Treatment on the Electrical and Thermal Resistivity and Thermo-Electric Potential of Some Steels," by Mr. E. D. Campbell and Mr. W. C. Dowd; (4) "New Impact Testing Experiments," by Mr. G. Charpy and Mr. A. Cornu-Thenard; (5) "Heat Treatment of Grey Cast Iron," by Mr. J. E. Hurst; (6) "Effect of Mass on Heat Treatment," by Mr. E. Law; (7) "Investigation upon a Cast of Acid Open-Hearth Steel," by Mr. T. D. Morgans and Mr. F. Rogers; (8) "The Acid Open-Hearth Process," by Mr. F. Rogers; (9) "The Eggertz Test for Combined Carbon in Steel," by Mr. J. H. Whiteley; (10) "Failure of Boiler Plates in Service and Investigation of Stresses occurring in Riveted Joints," by Mr. E. B. Wolff.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, SEPTEMBER 14, 1917.

THE CASE FOR THE ELECTRON.

As the result of exhaustive researches, which have now extended over a period of at least thirty-six years, physicists have been forced to the conclusion that electricity is atomic in structure, and the confidence with which they hold to this deduction is not much removed from that reposed in the doctrine of the impossibility of a successful perpetual-motion machine. Whilst, however, the results of the numerous careful investigations made during the past few years are conclusive to those who have studied them, there are many engineers who, in the press of their other engagements, have been unable to follow the progress of these researches, and it may accordingly be of interest to our readers to have a summary of some of the simpler arguments adduced in favour of the hypothesis.

It has long been known that in such an operation as electro-plating the weight of metal deposited is directly proportional to the quantity of electricity passed through the bath, and in 1834 Faraday proved that in the case of metals having the same chemical valency the weight of each deposited by the passage of a stated quantity of electricity was exactly proportional to the respective atomic weights. Thus the passage of 96,500 coulombs will deposit 39.1 grammes of potassium or 23 grammes of sodium, whilst with divalent metals twice as much electricity will be required to deposit a weight equal to the atomic weight in grammes, and with trivalent metals three times as much; so that to deposit 27 grammes of aluminium the quantity of electricity required will be $3 \times 96{,}500$ coulombs. These experimental results are most simply co-ordinated if it be assumed that electricity has an atomic structure, and that each atom of a monovalent metal carries with it in electrolysis one atom of electricity, each divalent atom two atoms of electricity, and each trivalent atom three atoms of electricity.* This suggestion was definitely made by Helmholtz, in 1881, though we believe it originated earlier, and the name electron was coined for this atom of electricity by the late G. Johnstone Stoney.

The evidence in favour of the above view has since been considerably strengthened, because metallic ions have been obtained in the vacuum tube. In this case the ions of the metal move with great velocities in straight lines, and when they strike against a photographic plate affect it so that, on development, a black patch appears at the point of impact. By placing in the path of these ions a screen having an extremely small hole in it, only a very small pencil of these moving ions is able to reach the photographic plate. It is found by experiment that if this pencil be caused to traverse intense magnetic and electric fields, it is deflected. The slower moving atoms are deflected most by the electric force since they are longest exposed to it, whilst, on the other hand, the magnetic force exerted on the ion increases with the velocity of the latter. The result is that a curve and not a spot appears on the plate when this is developed. The amount of deflection depends, however, not merely on the velocity of the particle, but also on the charge carried by it. If this charge varied continuously from atom to atom, a brush rather than a well-defined curve would, in all cases, be shown by the photographic plate after development. It turns out, however, that by suitable precautions a curve as sharp and clearly defined as a hair can be obtained. Cases arise in which some of the ions carry more than one charge, but the result on the plate is two or more distinct and sharply defined curves. There is no indication of any continuous variation of the charge from atom to atom. Each atom carries, say, either one, two, or three unit charges; never one and a quarter charges, or two and seven-eighths of a charge. Hence it is a reasonable conclusion that the results observed in electrolysis are not merely obtained by averaging a number of charges varying from atom to atom, but that here also each atom carries, say, one, two or three unit charges of electricity, and never a fraction of these amounts. The laws of electrolysis thus afford cogent evidence in favour of the atomic nature of electricity.

Another kind of research, which led to the same result, was originated by Crookes, who in the course of experiments on vacuum tubes was driven to the conclusion that the rays observed in such tubes at high vacua consisted of a stream of little electrified particles, and he was pretty sure that these particles were not particles of ordinary matter. For them he coined the name "radiant matter." These rays shot out, he found, in straight lines from the cathode, causing phosphorescence of the glass of the tube where they struck it. An obstacle placed in their path cast a sharp shadow. This view of Crookes, which is now universally accepted, was sharply criticised at the time, particularly in Germany, where it was held that the rays were essentially a disturbance in the luminiferous ether, and with some air of triumph the German experimenters demonstrated that the rays could pass through thin sheets of aluminium, a discovery which they held to be conclusive evidence of the falsity of Crookes' hypothesis that the rays consisted of electrified particles. This reasoning would have been more decisive if Crookes had claimed that his particles were ordinary gaseous particles. If they were much smaller than these there was no reason why they should not be able to penetrate through the interstices between the

* Strictly speaking, as the electron is a negative particle it would be more precise to say that a monovalent metallic ion has lost one atom of electricity, whilst a divalent ion has lost two, but the argument is of course quite independent of the sign of the charge.

molecules of the aluminium, although these were impervious to air or other gases.

Crookes had shown, moreover, that the rays, whatever they were, were easily deviated by a magnet, which has no similar action on light. Moreover, the rays could not be diffracted, as light would be, an argument the force of which is enhanced by the later discovery that the Röntgen rays, which are generated when the cathode rays impinge on a metallic target, can be made to yield diffraction patterns, proving them to be a form of light with extremely small but perfectly determinate wave-lengths. These Röntgen rays are not deviated by a magnet, and hence it is, to say the least, extremely improbable that the cathode rays have a similar character. Moreover, the cathode rays, if concentrated on a target, can raise the temperature of the point of impact to such an extent as to fuse the surface of the most refractory metal, acting in this respect exactly as if they were a stream of projectiles.

Again, both theory and experiment have shown that a rapidly moving particle charged with electricity would be acted on by a magnet exactly as an equivalent continuous current of electricity would be, so that the behaviour of the cathode rays in regard to a magnet is what would be expected were they a stream of charged particles. That they do carry a charge was proved by directing them into a hollow metallic receiver connected to an electroscope, which showed that the receiver acquired a negative charge of electricity.

Whilst, however, the evidence was conclusive that these rays were actually a stream of electrified particles, there was no direct evidence as to the precise nature of these particles. They might conceivably be atoms or molecules of a gas, though Crookes had been forced to a contrary conclusion, and the fact that the rays would pass through a thin sheet of aluminium was strong evidence that the particles, whatever they were, were of finer structure than ordinary atoms or molecules.

The corpuscles constituting the cathode rays were, as stated, found to be deflected under magnetic forces. They were also, at a much later date, proved to be deflected on passing through an electric field produced by two parallel plates coupled to opposite poles of a battery. Astronomers determine the masses of the stars by observing their deflections in the gravitational field of force due to their mutual attractions. The problem in the case of the corpuscle was more complicated. The deflection of a particle passing between oppositely charged plates will be greater the greater the charge carried per unit of mass, since the deviating force acting is proportional to the quantity of electricity, and the inertia or reluctance to motion of the particle is measured by its mass. This deflection will obviously be greater the greater the time during which the deviating force acts; that is to say, the greater the time taken to pass between the oppositely electrified plates. This time is, of course, inversely proportional to the speed of particle, and hence, if this were known, the amount of electricity carried per unit of mass could be calculated from the observed deflection, just as Newton calculated the force per unit of mass acting on the moon from its observed deviation from the tangent to its path.

The fact that the cathode rays were deflected also by the magnetic field and according to a different law than that deviating them in an electric field made it possible to determine their speed. The problem, it will be seen, contained two unknown quantities, viz., the charge carried per unit of mass, which is denoted by $\frac{e}{m}$, and the speed of motion v. The deflection in the electric field gave one equation between these two unknown quantities, and that in the magnetic field another. Solving these two simultaneous equations both $\frac{e}{m}$ and v were determined. The experiments have been made and remade again and again, with great care, and have shown conclusively that in the case of cathode rays the charge carried per unit of mass is some 1,700 times as great as is carried by a unit mass of hydrogen in electrolysis. Hence either the charge e is 1,700 times as great as the charge of the hydrogen atom in electrolysis or the mass of the corpuscle is only $\frac{1}{1700}$ that of the hydrogen atom.

Further experiment showed that similar electrified particles having the same ratio $\frac{e}{m}$ were obtainable in many other ways, as well as in the form of cathode rays. The electricity liberated when ultra-violet light is directed on to a zinc plate was found to be similarly constituted; the carriers, whatever they were, having the same ratio $\frac{e}{m}$. In this case the particles move but slowly, and such slowly-moving particles are found to attach themselves to the molecules of any gas in which they may be liberated. This fact provided a means of determining the value of e, and since the ratio $\frac{e}{m}$ was already known, the value of e gave that of m. The plan adopted depended on an exceedingly curious fact established by Aitken, viz., that in dust-free air moisture will not separate out as mist or raindrops, even though the air be highly supersaturated. Thus in one experiment exhibited at a meeting of the Royal Society of Edinburgh, in 1880, steam from a boiler was led into two equal glass globes, one filled with the ordinary air of the room and the other with air which had been carefully filtered and was dust-free. On turning on the steam the one globe filled instantly with a dense cloud, whilst in the other not a trace was to be seen. The explanation given by Lord Kelvin is based on the fact that the surface film of every liquid is in a state of tension, and to this "surface tension" all capillary phenomena are due. Hence work must be done to increase the surface of a liquid, and, correspondingly, such a surface constitutes a store of energy. This energy is directly proportional to the extent of the surface, and hence, in the case of a drop of water, its amount is proportional to the square of the radius. On the other hand, the supply of energy needed to evaporate a drop of water varies with its weight; that is to say, as the cube of the radius. Hence, by taking the radius small enough, the store of energy in its surface film becomes more than is required to evaporate the drop, so that a very minute drop of water, if it can be formed in any way, evaporates automatically.

It is found that a soap bubble will increase in size if electrified, the surface tension being partially balanced by the electric forces called into play, and thus the work available by letting the electrified bubble contract is correspondingly reduced. Hence it was thought that particles too small in the normal state to permit of water condensing on them to form mist might act as condensation nuclei if they were electrified, and this proved to be the case.

Dust-free air supersaturated with moisture was found to remain quite clear; whilst if corpuscles were liberated in it by, say, the action of ultra-violet light on zinc a fine mist appeared at once. The weight of the droplets thus formed could be measured by observing the rate at which they fell through still air, whilst the charge each carried could then be measured by subjecting them to the action of an electric field, tending to drive up against gravity the charge and the droplet carrying it. The electric force acting on the drop was proportional to the charge carried, and the force dragging it down to the weight of the drop. By balancing the two the electric force was determined, giving at once the value of the charge carried. Experiments based on this principle have now been made with great precision, and have shown that the charge carried is in all cases 4.774×10^{-10} electrostatic units of electricity, and is thus equal in numerical value to that carried by the hydrogen atom in electrolysis. Hence the value of m is $\frac{1}{1700}$ that of the mass of the hydrogen atom. How much of this corpuscular mass is ordinary gravitational mass is another question.

The conception that the apparent mass of a body may be much greater than that due to its weight is of course, not new, having long been familiar to naval architects. Mass simply measures resistance to accelerations, and the inertia of a body immersed in a fluid, even if this be ideally perfect, is much greater than that due to the mere weight of the body. Experiments indicate that in the case of the cathode ray there is little, if any, ordinary gravitational inertia, and point to the conclusion that these rays are disembodied atoms of electricity, rent from their usual resting-places in atoms of matter.

Experiments in another field, that of spectroscopy, lead to quite similar conclusions. Zeeman found that certain spectral lines when exposed to the magnetic field became triplets. Accurate measurements of the distances between these components showed that they would be accounted for if the original single line of the spectrum was due to the motion within the atom of electrons similar in every regard to those believed to constitute the cathode rays.

Summing up, it will be seen that a very large variety of independent experimental data is co-ordinated if electricity has an atomic structure; that the most delicate experiments have shown that the charge carried by individual atoms is always a multiple of a certain unit, increasing not continuously but by sudden jumps—a fact easily intelligible if electricity is atomic in structure; and that, moreover, it has been possible to make direct and precise measurements of the size of this atom. The only known criterion of the truth of a scientific theory is "Does it work?" and the evidence accumulated since Sir J. J. Thomson demonstrated some twenty years ago the true nature of the cathode rays has shown that the theory that electricity is atomic in structure "works" most satisfactorily in the most diverse fields, covering every department of experimental physics.

THE DEVELOPMENT OF CONTINENTAL SHIPPING AND HARBOURS.

THE neutral nations would be more than human if they did not see in the U-boat campaign an opening for them to secure a greater share in the carrying trade of the world, which has hitherto been largely in British hands. After the declaratiCn of peace there will be an immense demand for raw materials to stock the factories of Europe, and of manufactured goods to supply the needs of distant countries. Neither Britain nor Germany will be able to furnish the necessary tonnage, and cargoes will be offered to every shipowner who can carry them. While the combatants are devoting all their energies to the war the opportunity occurs for the neutrals to prepare for the future, by enlarging their harbours and by building new vessels. In Holland a new scheme has been prepared for the deepening of the waterway from Rotterdam to Dordrecht, to make that ancient town a regular seaport. The new waterway will follow an arm of the Meuse, which at the east end of the island of Roozenburg branches off from the Rotterdam channel. The distance from that point to the harbour at Dordrecht is 27 km., and the channel is to be deepened so as to allow vessels of 8 m. (26 ft. 3 in.) draught to proceed to Dordrecht. The new channel will be from 200 m. to 260 m. broad, with a narrower channel, 100 m. broad, 7½ m. (24 ft. 8 in.) deep, the middle of which, for a breadth of 50 m. (164 ft.) will be 8½ m. (28 ft.) deep. The cost is calculated at 4,000,000 gulden (330,000*l.*). Holland has already started a new passenger line from Amsterdam to America, and through the Panama Canal to India; this route has been chosen on account of the war, but is not unlikely to be kept in the future. Another new Dutch transpacific line is to start from San Francisco and call at Honolulu, Yokohama, Nagasaki, Hong-Kong and Singapore. Most of the Dutch steamer companies have paid enormous dividends for 1916, four concerns paying no less than 100 per cent.; the Holland-America line has paid 55 per cent., the Zeewart Company 50 per cent., &c. Still the business of Holland's most important port, Rotterdam, has receded very materially during the war, and the number of arrivals and sailings has fallen to what it was close upon fifty years ago, as will appear from the following table:—

	Number of Vessels.	Tons.
1870	2,973	1,026,348
1890	4,535	2,918,425
1900	7,268	6,326,901
1910	9,368	10,658,831
1913	10,203	12,785,861
1914	7,303	9,188,615
1915	3,644	4,153,682
1916	2,979	3,191,830

Sweden is another country which is exerting herself vigorously to facilitate the development of her shipping, and in this connection the important harbour plans and extensions of her largest ports are of interest. At Gothenburg the necessity has been felt for some time for the construction of a deep-water port which would avoid certain drawbacks from which the present harbour accommodation suffers. A plan has now been prepared for a harbour at Käringberget. The rock bottom generally lies at from 9 m. to 13 m. (29 ft. 6 in. to 42 ft. 8 in.) below water-level, and a depth of 12 m. alongside the quay is easily attainable, this being 3 m. more than what has hitherto been available in the central harbour. This harbour is in the first place intended for overseas traffic, and as a transit port for Baltic and canal boats, but it will hardly be suitable for the projected Anglo-Swedish steam ferry connection on account of the extensive railway accommodation required for the latter, which it would be advisable to keep separate from a commercial harbour. The locality in question is protected from the prevalent south-west winds. The length of quays with the full 12 m. depth, according to the present plan, will amount in the aggregate to 3,400 m. (11,200 ft.), in addition to which there are 915 m. (3,000 ft.) of quay with a depth varying from 4.8 m. (16 ft.) to 9 m. (29 ft. 6 in.). The cost is estimated at 1,100,000*l.*

In Stockholm a large harbour extension is under consideration. Other Swedish towns are extending their harbour accommodation materially. The Malmö free harbour will be located east and north of the Mjhavn pier in immediate connection with the present harbour, and the necessary area will be obtained by dredging and filling up. The depth of water at the entrance and in the basin will be 9.5 m. (31 ft. 2 in.) which for the present is considered sufficient. The plant will comprise 17 electric cranes of 2½ tons capacity, 9,000 sq. m. area of sheds besides warehouses, and a silo of 10,000 tons capacity. The cost was estimated at about 520,000*l.* before the war.

Swedish shipyards are exceedingly busy, most steamship companies doing their utmost to increase their tonnage. The Eriksberg yard has secured contracts from the Svenska Lloyd Company for three steel cargo steamers of 3,250 tons deadweight each, to Lloyd's highest class. The same yard is building three other cargo steamers of 1,000 tons deadweight each and two of 1,800 tons. The Svenska Lloyd has a number of other steamers in course of construction; the Oscarshamn yard is building the Catalonia, 2,900 tons, and has delivered the Marsilia, 2,985 tons; the same yard has further contracts for one steamer of 2,500 tons and two of 2,400 tons each. The Lindholmen yard is building the Scotia, 3,200 tons, and the Bergsund yard the Holmia, 2,900 tons, &c. All the boats have to be ready in the course of the next three years, and when delivered the company will, barring accidents, have 51 steamers with an aggregate tonnage of 113,140 tons deadweight. In addition, the Svenska Lloyd has just secured a controlling interest in the Nordiska Raderiaktiebolag, Gothenburg. At the new Öresund yard in Landscrona the keels have been laid for the first 10 steamers, each of 1,800 tons.

The largest Swedish-built motor vessel was some little time ago delivered by the Södra yard in Stockholm to a Gothenburg firm; it is built to German Lloyd's highest class, the dimensions being 227 ft. length, 34 ft. breadth and 14.5 ft. draught with full cargo. There are two Diesel motors, from the Swedish Diesel Company, of an aggregate power of 875 i.h.p., and the speed is 10 knots.

The Norwegian yards are very fully employed. The Moss yard has recently launched a couple of boats of 1,850 tons deadweight, and the building of a third sister vessel has at once been commenced. Norwegian shipping has, on the whole, done exceedingly well during the war, and in the course of 1916 the Norwegian merchant marine has earned far larger profits than during any previous year. The increase in tonnage during the year was not of much importance, being only 35 vessels, of 5,880 tons, while the losses were very great.

In Spain there has been commenced, in a yard at Valencia, the building of wooden vessels for several Spanish owners, to designs of a Philadelphia expert; the sizes will be from 480 tons to 1,000 tons deadweight, and the vessels will be fitted with Diesel motors and electric auxiliary machinery. Another Spanish yard, the Vea-Murginia, in Cadiz, which has been lying empty for the last decade, has been sold to a Spanish shipping concern for a sum of 1,300,000 pesetas. The new owners will immediately commence the building of six cargo boats of 6,000 tons deadweight each, and a number of extensions have been decided upon, including a floating dock with a capacity of 20,000 tons, new slips, &c.

While the neutral nations are busy increasing their harbours and their tonnage, our enemies and our Continental Allies are quite alive to the necessities of the future. Germany is clearly much concerned as to the position of her merchant marine after the war. She views with apprehension the progress made by other nations, and special attention is being paid to the amalgamations among English shipping companies. In the meantime a German estimate of the shipping losses during the war may be of some interest, although it cannot claim complete accuracy. The number of vessels lost as prizes, from mines, or torpedoing, is put at 152, with an aggregate tonnage of 410,600 tons; in hostile harbours there remain 311 vessels, of an aggregate tonnage of 807,200 tons, but this does not include vessels lying in the ports of the United States, 32 vessels with an aggregate tonnage of 364,000 tons, which must be deducted from the 621 vessels, of 2,341,000 tons, put down as remaining in neutral ports, from which also those in China and Siam now have to be deducted. This makes a total loss of some 1,600,000 tons out of a total of 5,550,000 tons at the beginning of the war, in addition to which some 2,000,000 tons have been lying idle in neutral ports for more than three years; as has also the greater portion of the tonnage in German ports.

Vague rumours have been circulated about the large amount of tonnage which has been built at German yards during the war, but careful students of German affairs are extremely sceptical on this point, as about all other reports of Germany working to stock in other industries so as to be able to throw large quantities of manufactured goods on the market directly the war is over. There has been neither labour, nor raw materials, nor money for such purposes, and neutrals who have had frequent opportunity of visiting the industrial towns during the war are convinced that Germany is literally empty.

The State aid to German shipping, as now projected, entails a grant of some 1,250,000,000 marks in all, the money, as far as the shipping companies are concerned, being intended for the purchase of new tonnage. Although the terms financially may not leave much to be desired, there are unpleasant prospects of State control looming in the future. Of compensation for the direct losses arising from the war there seems to be no prospect at present. Of course a number of orders have been placed with the home yards, but comparatively little is known as to the state of advancement of the contracts. Herr Hugo Stinnes continues to show his confidence in shipping, and has ordered five steamers from the Vulkan yard at Vegesack, three of 12,500 tons each, one of 5,000 tons and one of 4,000 tons. This yard, in addition to these five boats, has six more building of 12,500 tons each, most of which have to be ready within a year after the conclusion of peace. The Tönning shipyard has been converted into a company, with a capital of 1,750,000 marks, for building standard steamers, and 15, of an aggregate tonnage of 55,000 tons, have already been ordered. A floating dock will also be constructed. In the interests of shipping harbour extensions have been planned in several places; in Bremen, for instance, it is proposed to deepen harbour No. 1 from 8 m. to 8½ m., and harbours Nos. 2 and 3 from 8 m. to 9½ m., in addition to which the south pier of harbour No. 1 will be rebuilt.

Another outcome of the war is the formation of a German Lloyd's on similar lines, as far as possible, to those of the English Lloyd's, with headquarters in Hamburg and branches in Bremen and Berlin. Although Germany felt herself at a disadvantage in this respect before the war, no independent movement was then contemplated. The annual expense is calculated at 2,000,000 marks, of which one-fourth is expected to be covered by annual subscriptions from some 500 members, whilst the balance will have to be provided in other ways.

Austrian shipping is naturally faring badly during the war, and for most of the companies with a large portion of their tonnage lying in foreign ports the payment of a dividend has been out of the question. This applies to the Austrian Lloyd, the Tripkovitch Company, the Free Shipping Company and the Austro-American line. The Dalmatia, with a fleet of some 30 boats engaged in the coasting traffic, was able to pay 6 per cent. last year, against 5 per cent. for the preceding year. The Austrian steamship owners are preparing two combines or unions, one for liner concerns, with some 400,000 tons, and one for tramp boats, with some 600,000 tons. This is partly done to anticipate any State interference.

The Roumanian merchant marine is still in its infancy, having in reality only existed a couple of decades, and in the year before the war it comprised only a dozen steamers. There were the Orient line and the Occident line, the former trading to Constantinople, Smyrna, Piræus and Alexandria, with five boats, averaging 7,000 tons and a speed of 18½ knots. The Occident line traded between the Mediterranean ports, and even to Northern Europe, England, Belgium, Holland and Germany; the boats were about 2,200 tons, and seven in number. The shipping traffic of Roumania, however, is by no means without importance, and has increased largely during the last few years. In 1913, for instance, the vessels entering all the Roumanian harbours on the Danube included 90 French, 6,876 Austrian and 120 German vessels. Vast sums have been voted by Bavaria for the improvement of the Danube waterway, and other large schemes are under consideration. Should Roumania after the war choose to deal with the Western nations in preference to developing its up-river traffic, it is feared in Germany that much of the money devoted and to be devoted to the improvement of the Danube waterway will have been expended in vain.

Italy has followed the example of England in the amalgamation of several shipping concerns, viz., the Peirce shipping firm and the Sicula Americana, which jointly have taken over one-half of the capital, which is fixed at 100,000,000 lire, whilst the other half has been provided by the Navigazione Italiana and the Italia Company. The new company will commence with a fleet of 14 of Italy's largest boats, but additional tonnage will be procured as soon as practicable. Naples will be the headquarters of the new company, which bears the name Transoceanica.

It is becoming more and more difficult to form a satisfactory estimate of the conditions of business after the war. That there will be an enormous demand for all kinds of raw material and manufactured goods is quite certain, for the world has been living on its means—or beyond its means—for three years. Peace is not yet in sight, and even after it is declared it will be a considerable time before we can revert to our normal commercial activity, for demobilisation is always a slow business. Apart altogether from the losses caused by U-boats, there has been a steady reduction of tonnage by storm, fire, collision and stranding, while the customary replacement has dwindled to comparatively small figures. A great increase of tonnage is urgently called for, and however active the neutral nations may be in shipbuilding, it is certain that they cannot supply more than a small fraction of what is needed. The demand for new shipping after the war will be most urgent, and for some time the question of cost will not interfere with the placing of orders. But that happy condition cannot continue for ever. The combination of dear money, dear material and dear labour must eventually cause a slackening of demand. No one can say when that will come, but it is fair to assume that it will come later in the shipbuilding trade than in many others. So long as manufacture is brisk we must have vessels to transport the raw materials and the goods.

LOSS OF TIME AT MEAL HOURS IN SHIPYARDS.

AMONG the many problems which confront the manager of any large shipbuilding works there is perhaps none which is more difficult to solve in a satisfactory manner than that of keeping the men at work until the stopping whistle sounds, and of ensuring a prompt start after the whistle has blown for the resumption of work after a meal-time stoppage. The present shortage of labour, and the consequent competition for the available men, have greatly enhanced the difficulties of employers in dealing with the workers—a very large proportion of whom do not hesitate to take full advantage of their present position of indispensability and of the reluctance of most employers to prosecute this class of slacker at the Munitions Courts. That the loss of time is serious will be evident from the fact that in a yard employing 3,000 men, a loss of seven minutes, six times a day, would amount to no less than 2,100 hours per day—and at the present time seven minutes is by no means an exaggerated estimate of the time lost before and after stopping and starting times. At the present, when every effort is so urgently required for the production of war and merchant vessels, the seriousness of this largely preventable waste does not require to be laboured, but in view of the fact that it is usual for writers on this subject to deal with it solely from the point of view of works discipline, it may be of interest to glance at it from a broader viewpoint, in order to investigate some of the contributory causes and to make sure of the justice of the grounds upon which disciplinary measures may be based.

It is, first of all, essential that the stoppage for meals should be sufficiently long to enable the workers to have a good meal and a smoke in reasonable comfort. In all large works there are three classes of worker to consider, viz., those whose homes are sufficiently near to the works to enable them to travel home for meals, those who cannot get home but who carry their food to, and eat it within, the works, and those who have their meals in the eating-houses generally to be found close to all large works. In the majority of shipyards in Scotland the stoppages for breakfast and dinner are each of three-quarters of an hour duration, and while this is a sufficient time for those workers who come within the second and third categories above, it is, as a rule, too short for those who travel home, unless the service of cars or other means of locomotion is specially organised to meet their needs. In many of the large yards it takes quite five minutes' hard walking to reach the gates from the building berths, fitting-out basin or outlying parts of the yard, and as a general rule tickets have to be deposited and lifted during the meal-time stoppage at a point at or near to the job on which the worker is engaged. This entails a loss of ten minutes in each meal-time stoppage, and leaves only thirty-five minutes for the journeys between the works and the home, and for the consumption of the meal. This shortage of time, aggravated as it often is by a transport service wholly inadequate for the needs of those of the workers who arrive at the bus, tramway, or railway lines a few minutes after the stopping whistle, is one of the chief causes of men leaving work and making for the gate before the stopping whistle, and for their arriving back tired and disinclined for an immediate resumption of work. With regard to those who carry their food and make tea for themselves in the works, the main difficulty will generally be found to lie in the supply of boiling water or the facilities for boiling it. Where boiling water is provided the supply is often quite inadequate, and thus a rush to be first at the taps is quite inevitable. It is no uncommon thing to find that while the total hot-water supply for the works is ample, the supply at certain points is not equal to the demand, and as the point of maximum demand may vary with the disposition of the work, this matter should not be lost sight of in installing the water boilers. The case of those who have their meals in dining rooms outside the works does not come directly within the sphere of the employer and need not be discussed here.

It is quite certain that any effort to increase the meal-time stoppages to, say, one hour each would be strenuously opposed by the workers if this involved working the extra half-hour later in the evening, and in any case the extra time would only be of real benefit to those who travelled. It should further be noted that extension of the meal-time stoppage would considerably increase the number of those who could travel within the time, and might well aggravate the trouble which it is desired to cure. At the present time no reduction in the number of hours worked is desirable, and with the existing arrangements for meal times it would seem that the most direct contribution toward the solution of the problem of lost time which the employer can make is to improve the transport facilities for those whose homes are within travelling distance in the time available, and ensure reasonable facilities for those who take their meals within the works.

In its broader aspect the solution of the problem involves the provision of suitable housing accommodation within the required radius of the works—but in many cases this is not possible owing to the position of the works and the character of the surroundings. It therefore becomes a question whether the general adoption of a scheme for the provision of suitable meals within the works would not well repay firms employing large numbers of hands. Mainly as a consequence of war conditions this scheme has recently been somewhat extensively adopted for women workers, but in many cases the catering has been done by voluntary labour—a form of service which would probably not be available after the war, and which in any case is not sufficiently within the control of the employers and workers for peace-time conditions. There is no reason why similar arrangements could not be made for the feeding of the workmen at a dining hall within the works. Such an institution, run upon sound business lines by a committee representing the workers and the employers, should hold out excellent prospects of success in the matter of providing suitable and reasonably-priced meals for all those who are unable to travel to their homes at meal times. Apart from the obvious advantage gained in the removal of the incentive to leave work in order to be at or near the gate when the whistle blows, there would be the additional advantages of keeping the men within the works and on wet days in a dry and comfortable shelter—two factors which would contribute to steadier timekeeping and more comfortable work.

While there is undoubtedly a very great deal of time lost at meal times by men who have no excuse at all except that they simply do as others do, yet what has been said will show that in many cases there is a very real reason for the loss of time which occurs at meal times, and while the reasons given cannot be held to constitute a justification, yet they point the way to needed improvement within the control of the employer, and the carrying out of which in whole or in part would, at least, aid in the solution of a problem which is a bugbear to every shipyard manager.

THE LATE MR. PERCY GRAHAM BUCHANAN WESTMACOTT.

WE regret to have to record the death, which occurred at his residence, "Rosemount," Ascot, on Monday last, the 10th inst., of Mr. Percy Graham Buchanan Westmacott, a former director of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited.

Mr. Westmacott was the youngest son of the late Mr. Henry Westmacott, of Whetstone, Middlesex, and was born at Edinburgh on September 11, 1830. After a course of study at the Edinburgh University he served his apprenticeship at Elswick and also in the marine engine works of Messrs. Miller, Ravenshill and Co., Blackwall. In 1851 he entered the Elswick Works in the capacity of draughtsman, being appointed a few years later—namely, in 1853—manager of the engine department. In 1863 Mr. Westmacott was taken into partnership, and on the conversion of the Elswick Works into a limited company, in 1883, he became a managing director. He remained a director of the company from 1883 to 1910, when he retired.

As the above dates show, practically the whole of Mr. Westmacott's life as an engineer was spent at the Elswick Works. As previously mentioned, he entered these works in 1851, about four years after they had been started. Upon the appointment of Mr. W. G. Armstrong (as he then was) to superintend the manufacture of guns at Woolwich Arsenal in 1859, Mr. Westmacott was entrusted with the sole technical management of the engine works at Elswick, which at that time formed the principal section of the Armstrong establishment. The blast-furnaces and iron foundry had shortly before been inaugurated; they had been designed and built by the deceased in conjunction with the late Mr. Thomas Clark (who, when at Messrs. Hawks, Crawshay and Co.'s works, manufactured the cast-iron arches of the High-Level Bridge at Newcastle), and with the late Mr. G. Hutchinson, the head of the drawing office and assistant manager at Elswick. The Elswick blast-furnaces were put out of operation in 1899.

In the early years of their activity the Elswick Works acquired repute in the manufacture of lifting machinery, one of their most important specialities being the construction of hydraulic cranes. Mr. Westmacott greatly contributed to the development of this branch of the Elswick business. In June, 1866, he completed a long series of experiments, which he had been carrying out for a number of years, in the conveyance of grain. In these experiments he resorted to horizontal bands of rubber and canvas, in place of the endless screws which were then used exclusively, his innovation leading to a great saving in power. As a result of these experiments the grain-conveying and elevating machinery of the grain warehouses at Waterloo Dock, Liverpool, and at Birkenhead, was designed and was constructed by his firm. This plant constituted a most important advance in the development of mechanical appliances for the handling of grain and similar materials, and it was fully described in a paper read by Mr. Westmacott at the meeting of the Institution of Mechanical Engineers, held at Newcastle-on-Tyne in 1869.*

Mr. Westmacott was also largely responsible for the introduction of hydraulic power in docks for operating the dock and lock gates, the levelling sluices, capstans, swing bridges, &c., now so universally used.

In 1868 Mr. Westmacott designed, in conjunction with the late Mr. T. E. Harrison, then engineer to the North-Eastern Railway, the swing bridge across the Ouse, near Selby, and later a similar bridge at Naburn. The swing bridge across the Tyne, at Newcastle, was also built largely under his direction, in conjunction with the late Mr. Hamilton Rendel, who at that time was taking an active part in the management of the engine works at Elswick. Mr. Westmacott gave a great deal of attention to the bringing out of an efficient capstan for hauling wagons, the result being the "turnover" type which is now very generally adopted; he was also principally instrumental in introducing to the authorities at the port of Antwerp hydraulic power in substitution for the hand-power machinery at their older docks. Almost all the principal docks on the Thames, the docks in the South Wales ports, and in other parts of the United Kingdom, were equipped with machinery for operating the locks and for the loading and unloading of cargo at the suggestion of Mr. Westmacott, acting in conjunction with the local engineers. The earlier giant cranes, such as the 100-ton crane at Barrow, the 160-ton cranes at Spezia, Malta, Venice and Taranto, are among some of the examples of the work carried out under his direction, to which should be added the hydraulic installations for dealing with cargo fitted in the large P. and O. passenger liners, beginning with the steamship Massilia, and continued for many years.

The biography of Mr. Westmacott runs to a large extent parallel with the history of the Elswick Works in the first period of their activity. These works dealt at first exclusively with engineering construction. Following upon his first successful experiments, recorded above, Mr. Westmacott devoted much of his activity to the construction of machinery for the rapid conveying of goods of all

* This paper was reprinted in ENGINEERING, vol. ix, pp. 51, 70 and 88.

kinds. As an instance of this we may quote from the presidential address which he delivered at the Leeds meeting of the Institution of Mechanical Engineers, in August, 1882. He stated: "The nation or community which applies its inventive faculties, its powers of adaptation and construction to the moving of materials for useful purposes with the least amount of manual labour and waste—in a word, which extends and cheapens transport by land and water—is in the van of all real work, substantial progress, wealth and civilisation." But Mr. Westmacott, nevertheless, remained always fully alive to all engineering and social problems, and in the same address from which we take the above quotation he dealt with the turning to account of "waste" and with the abatement of the smoke nuisance, while he concluded by saying that "one of the duties which the acquirement of wealth and prosperity brings upon our nation is the duty of their defence; it behoves us never to neglect the taking of sufficient and constantly increasing precautions to protect our trade and to provide ourselves with every means for moving war materials by land and by water in times of difficulty with the least amount of manual labour."

At the Belgian meeting of the Institution of Mechanical Engineers, held in Liége, in the summer of 1883, Mr. Westmacott referred to their first president, George Stephenson, "whose broad-mindedness," he said, "would hardly have contemplated such a scene as was then enacted in Liége: a little army of British engineers sent forth from his old Institution, by invitation of our old ally, this time happily to meet in a field of industry, whose increasing richness is largely due to the development of his invention and his work." In this same address Mr. Westmacott called attention to railways and to the advantages of rapid transport; he also gave a few brief remarks on the power of ordnance. These remarks and his advice in the Leeds address concerning the protection of our trade are the only public references of his we can find which apply to artillery, a branch of manufacture in which Messrs. Armstrong have since acquired a world-wide renown. Mr. Westmacott worked with unremitting energy at the specialities which he had made his own, and his efforts largely contributed to the general success of the firm.

Mr. Westmacott was elected a member of the Institution of Mechanical Engineers in 1862; he was a member of the council from 1869 to 1875; vice-president from 1876 to 1881, and occupied the presidential chair in 1882 and 1883. He was elected a member of the Institution of Civil Engineers in 1861. For a few years, from 1878, he was a member of the Iron and Steel Institute.

In addition to his other activities, his services were also frequently in request as a witness before Parliamentary Committees, notably in connection with the various Thames Crossings Bills, including that relating to the building of the Tower Bridge. Mr. Westmacott paid great attention to the upkeep and manufacture of chains. On several occasions he gave expert evidence in the House of Commons Committee of Inquiry into the manufacture, testing and use of chain cables, and his evidence to a large extent influenced the legislation in the years 1871 and 1874 on that subject.

Mr. Westmacott was a man of strong artistic tastes and took particular interest in the work of the Barbizon School and of the Dutch School of Maris brothers and Israels, being well known in France and Belgium not only as a collector, but also as a personal friend of artists of the schools named. It is further interesting to note that Mr. Westmacott took great interest in the original volunteer movement, and that he raised and commanded for many years the 1st Newcastle-on-Tyne Engineer Volunteers.

NOTES.

Cementite Anomaly in Steel.

In 1909 Wologdin observed that the magnetic transformation of the cementite in iron was accompanied by a change in the direction of the dilatation curve. P. Chevenard, last June, presented a communication to the Paris Académie des Sciences (*Comptes Rendus*, vol. 164, pages 1,005 to 1,008) on a further study of this anomaly with the aid of his differential dilatometer. He prepared nine steel specimens, ranging in carbon from 0.1 per cent. up to 1.3 per cent., from Swedish iron and electrode carbon, in an electric furnace, and he determined the dilatation of his specimens, about 100 mm. (4 in.) in length, against a standard specimen of pure iron. The anomaly in the dilatation curve was quite comparable to that observed in ferro-nickel of the formula Fe_2Ni. The temperature at which the inflection in the curve was observed was, in all the steels about 210 deg. C. This is the temperature at which, according to Honda and Takagi's experiments of 1915, the magnetic transformation of cementite sets in. The Japanese investigators had found this transformation in white iron containing up to 3.5 per cent. of combined carbon, and Chevenard now observed it in steel of the low carbon percentage of 0.1. Above 300 deg. C., Chevenard's dilatation curve was practically a straight line. Within the carbon percentage mentioned (0.1 to 1.3) the amplitude of the anomaly was proportionate to the carbon percentage. The study of this irregularity in the dilatation curve can be utilised to determine the state—tempered, half-tempered or annealed—in which the carbon is left in the steel after treatment. The curves reproduced in the paper particularly refer to a steel of 0.83 per cent. of carbon, quenched at 800 deg. C. in cold water. Experiments were also made with specimens quenched in oil and mercury. When the steel had been tempered *en bloc*, the anomaly of the cementite was not discernible after annealing at 250 deg. C; but when the annealing temperature was raised, the anomaly appeared and attained its maximum amplitude at 700 deg. C.

The Formation of Diamonds.

For some years nothing seems to have been written on artificial diamonds, and the practically negative results of the new experiments of Professor Ruff, extending over three years, will hardly induce others to take up this study. The systematic research of Ruff (*Zeitschrift für Anorganische Chemie*, pages 73 to 105, May 15, 1917) was undertaken with the object of testing all the reactions likely to lead to a deposition of carbon, and he tried in particular, also, whether small real diamonds would grow under his experimental conditions. To bar the possibility of mistakes in view of the fact that any resulting growth would probably be minute, he purified these diamonds first with hydrofluoric, nitric and sulphuric acids, potassium nitrate, and, finally, with chlorine at 1,000 deg. C. He confirmed the statement of previous experimenters that small crystals of carborundum and alumina, even of quartz, had apparently been mistaken for diamonds, and his own artificial crystals, which fluoresced like diamonds in ultraviolet light and under α-radiation, were too small to admit of any conclusive analysis. In the first series of experiments he submitted gases (coal gas, acetylene, carbon tetrachloride, carbon monoxide, methane, &c.), alone or mixed with vapours (iodoform, benzene, carbon disulphide, &c.), to temperatures ranging from 200 deg. C. up to 3,500 deg. for 14 days, without obtaining more than an amorphous or graphite growth, except in one case. The carbon electrode arc of 5,000 volts alternating and 0.5 ampere, burning in liquid air for a very short time, yielded some very small crystals; arcs burning in flowing water and singing arcs did not give any distinct result, though the hard mass forming at sharp points left no residue when burnt. Experiments with liquids, heated up to 30 days, of paraffin, wax, graphitic acid, pitch, diphenylanine, &c., to which sometimes various metals (mercury, silver, silicon, aluminium, sodium, &c.) were added, were resultless. Quenching fused metals saturated with carbon at 1,350 deg. C. (iron alone or alloyed with high percentages of silicon, titanium, vanadium, tungsten; also cobalt, nickel or manganese) yielded very small diamonds, such as Moissan obtained; but an alloy of low melting-point (850 deg. C.), consisting of 100 parts by weight of iron, 100 parts of antimony, and 60 parts to 75 parts of manganese, yielded nothing, not even when a small diamond was embedded in the alloy, which was heated in a carbon arc. Fused silicates, &c., were no good either as solvents for carbon; this is particularly interesting, because Ruff especially tried silicates of the composition of the blue ground of Kimberley, in which diamonds occur. Nor did Ruff obtain any diamond-like crystals by electrolysing at 2,200 deg. fused calcium carbide, with which method Boismenu claimed to have been successful a few years ago. Finally, Ruff made experiments with a steel bomb, similar to that which Johnston and Adams had used in 1911 at Washington, at hydraulic pressures of 3,000 atmospheres, to heat liquids (oils, &c.) and gases (CO) for days and to produce a carbon arc in gas or in water. A carbon rod of 1.5 mm. diameter, heated in water by currents of 35 amperes at 80 volts, burned through in 5 seconds, but the drop of fused carbon merely solidified to a hard graphite. The war, in which Ruff's collaborator, Dr. Lauk, was killed at an early date, interrupted the experiments, which are not likely to be resumed.

Phosphorescent Zinc Sulphide.

Commenting quite recently upon investigations of the behaviour of radium luminous compounds, we remarked that it would be of great advantage if the luminosity of the zinc sulphide, in which the radium of luminous compounds is embedded, could be systematically studied in the first instance. There is quite an extensive literature on the phosphorescence of zinc sulphide, but not much agreement even as to the main facts. The latest contribution to these studies, published in the August issue of the Transactions of the Chemical Society, clearly brings out one of the reasons to account for contradictory statements and positively helps us on in other ways. Most of the various investigators did not sufficiently define the exact conditions under which they worked, and those conditions, especially of temperature, it is shown, are very important factors. The new research has been conducted at the University of Glasgow by Miss Elizabeth MacDougall and Messrs. Alfred W. Stewart and Robert Wright. Pure zinc sulphide, precipitated from zinc chloride or some other salt by ammonium sulphide, they find, shows no trace of phosphorescence—that was generally believed—but acquires it by being heated. Volatilised sulphide prepared by fusing zinc and sulphur in a crucible did phosphoresce, but the reactions did not admit of proper control; the experimenters returned to precipitation, therefore. Certain impurities of zinc sulphide have been considered to favour phosphorescence, others to prevent it. The experimenters introduced impurities, in traces or considerable percentages, mechanically or chemically, the latter either by working with salt mixtures, or by not washing the precipitate and by using an excess of the one or other reagent. They heated the precipitate to different temperatures for various periods, and obtained the best phosphorescence by heating to from 650 deg. to 900 deg. C. for 1½ hours; higher temperatures proved injurious; the resulting semi-crystalline product phosphoresced better than the amorphous or the crystallised; when the temperature was kept near 650 deg. the phosphorescence was blue, at higher temperatures green or yellow. Metallic impurities little affected the tint of the luminescence, except that manganese turned it into a golden-orange; this sulphide also showed an intense triboluminescence. The excitation of the phosphorescence requires exposure to light; magnesium, X-rays, cathode and Becquerel rays were tried. The first impact of cathode rays gave rise to a real flash of light; under continued exposure the whitish sulphide turned grey or brown, and the tint of the luminescence changed. Many impurities increased the phosphorescence of the pure sulphide. The presence of a chloride—which might lead to a secondary formation of zinc chloride—decidedly favoured it, iron prevented it. Washing, grinding or rubbing the sulphide diminished the phosphorescence. When cooled in liquid air the sulphide stored up light energy, and it may be said generally that the sulphide is in some way able to act as a reservoir for energy, which it can emit in particular light vibrations. The colder the sulphide, the more energy it can absorb, but the radiations must be of short wave-length. The physical condition of the sulphide is important and since grinding and washing diminish the

phosphorescence, the impurity which favours the phenomenon may form a surface film. The significant impurity, the experimenters conclude, is probably the chloride ion. This conclusion is not very convincing, and we are sorry not to have any definite statement that the research will be continued.

SHIPPING TRADE OF LONDON AND THE WAR.

Notwithstanding the war and the submarine menace, the shipping of the Port of London maintains a very satisfactory level. This is brought out clearly in the eighth annual report of the Port of London Authority, where it is shown that the inward foreign tonnage last year was only 17.7 per cent. less than in the preceding year, while the outward foreign tonnage was 12 per cent. less, the total foreign tonnage arriving and sailing being just over 13,000,000 tons, or 15.6 per cent. less. The coastwise tonnage has decreased rather more, due no doubt to the absence of tonnage rather than to any other cause, and the consequent necessity of coal and other supplies coming to the metropolis by rail. The decrease in coastwise tonnage is 21.8 per cent., including inward and outward tonnage. Thus the whole tonnage of the Port of London, totalling 18,380,212 tons, is 17.5 per cent. less than in the previous year. Due, however, to the appreciation of value of all imports and exports, the money value of the trade of the port has greatly increased. Indeed, this is the prevailing result in all the ports except those which are almost exclusively required for war purposes. London, according to this report, is to be credited with rather more than one-third of the value of the foreign imports and exports of the United Kingdom, Liverpool coming second, with a proportion not much inferior to that of the metropolis. Hull is third, her total being little more than one-sixth that of London, while Glasgow takes the next place, Manchester following immediately behind. The enterprise of the Port of London Authority is again shown by the great extent of storage capacity. Thus in March last there were stocked in warehouses 629,292 tons, as compared with 563,495 tons at the corresponding date of the previous year. Fairly satisfactory progress, notwithstanding the war, is recorded in connection with works and improvements. As regards the extension (south) of the Royal Albert Dock, it is recorded that the construction of the entrance lock, 800 ft. long by 100 ft. wide, by 45 ft. deep below Trinity high water, is approaching completion, and is ready for the installation of the lock gates, road bridge and necessary machinery. The main dock has been excavated to the full depth of 38 ft. over an area of 39 acres, and a further 14½ acres to within 3 ft. of full depth. Of the total quayage of 9,855 ft., the quay walls have been completed for a length of 8,800 ft., and the construction of a further 170 ft. is in hand. The piling for the seven reinforced concrete jetties on the south side of the dock, and the superstructure of one of them, are finished. The steel framing of the three transit sheds has been erected, and the construction of the new dry dock and the passage between the new dock and of the Royal Albert Dock is now well advanced. Owing to the Government requirements, however, all the steel work (including lock gates, bridges, and dry dock caisson) has had to be deferred. At Tilbury the main dock extension (about 17 acres of water) is now partially in use. The three transit sheds, with twelve 3-ton electric cranes, have been completed. Progress has been made with the new pumping installation for the dry docks; the gas producers and one set of main engines have been delivered, and are now being erected. Some progress has been made also with new sheds at other docks. At the Royal Albert Dock 43 new electric cranes have been completed and the new crane track and conduit finished. With the exception of two electric cranes requisitioned for war purposes, the equipment of the new works at the London Docks has been completed, as has also the reconstructed lock between the basin and the import dock at the East India Docks.

THE JAPANESE AIR SERVICE.—We read in *The London and China Telegraph* that the second aerodrome at Kamigahara, Gifu prefecture, is nearing completion. Three hangars and several other houses have been built,

A COMPARISON OF THE ACTIVATED SLUDGE AND THE IMHOFF TANK-TRICKLING FILTER PROCESSES OF SEWAGE TREATMENT.*

By HARRISON P. EDDY.†

THE activated sludge process, during the past two years, has taken a prominent place among methods of treating sewage. There have been many investigations to determine its capabilities, and the engineering profession is indebted to several investigators who have generously placed the data thus acquired at the disposal of those who may be interested.

The primary function of this process is the oxidation of organic matter through the agency of bacteria living in the presence of an ample supply of oxygen. As this is the primary function of the trickling filter also, it is important to know which is the more advantageous process. This can only be determined by a comparison of the respective costs of the two processes and an analysis of their individual advantages and disadvantages. In making such studies the local conditions in each case must be given their merited weight. In the comparison discussed in this paper the problem has been applied to the conditions existing at Fitchburg, Mass., where an Imhoff tank-trickling filter plant has been in successful operation since October, 1914.

Fitchburg has a population somewhat exceeding 40,000, and is situated on the north branch of Nashua River, which has a drainage area of about 65 sq. miles above the lower boundary of the city. The Nashua River flows into the Merrimac, from which the city of Lawrence is supplied with water after filtration. The drainage area of the Merrimac at this point is 4,663 square miles. The treatment of the sewage of Fitchburg (Fig. 1) was to prevent the pollution of the Nashua River

Fig. 1. PLAN OF TYPICAL TRICKLING FILTER PLANT FOR SEWAGE TREATMENT.

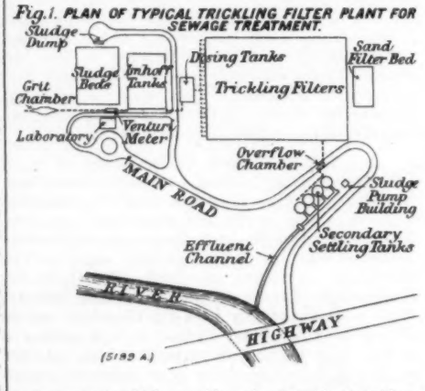
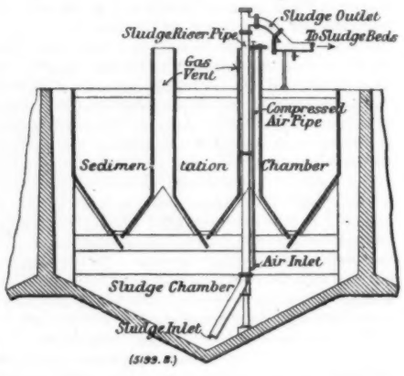


Fig. 2. CROSS SECTION OF IMHOFF TANK SHOWING AIR LIFT FOR SLUDGE.



to an extent which would make it objectionable or likely to become a nuisance. It was not necessary to secure an effluent having a high degree of bacterial purity.

The following discussion of construction and operation costs is based on studies of two treatment plants, one for the Imhoff tank-trickling filter process, and the other for the activated sludge process, both plants being designed to fulfil the same conditions. The trickling-filter plant has been based on the design and cost of the plant at Fitchburg, Mass., with such modifications as are necessary to reduce the costs to units suitable for comparison. The activated sludge plant has been designed to meet the same conditions, and where possible the same unit costs of construction have been employed. The design has been based upon experience gained from several experimental installations operated by the author during the past year and from data procured from Milwaukee and other reports.

Basis of Design.—Both plants have been designed to care for the sewage from a population of 55,000 persons. The average quantity of sewage is assumed to be 100 gallons *per capita* per day, equivalent to 5,500,000 gallons per 24 hours, and the detention period in Imhoff and humus tanks has been based upon a daytime flow of 125 per cent. of this average.

IMHOFF TANK-TRICKLING FILTER PLANT.

The description of the Imhoff tank-trickling filter plant as built at Fitchburg has been made rather complete, as it may be of interest and the data of value to some of the members of your society. The only material modification made in the Fitchburg design to aid in this comparison was to increase the size of the trickling filters and dosing tanks to serve a population of 55,000 instead of 40,000 persons. The remainder of the plant was built to serve a population of 55,000.

Grit Chamber.—A grit chamber is provided for the deposition of gravel and sand carried along in the combined sewers during and after storms, the design being such that a velocity of about 1 ft. per second can be maintained, so as to prevent the deposition of much putrescible matter. The purpose of removing the heavy inorganic material at this point is to prevent its retention in the Imhoff tanks, from which it would have to be removed at considerable expense if, as seems probable, it would not flow with the sludge to the suction pipe.

Screens.—At the lower end of the grit chamber a coarse rack of inclined bars about 1½ in. apart is provided to remove coarse trash, which might cause trouble in the pipe lines and Imhoff tanks.

Venturi Meter.—A venturi meter with suitable indicating and recording apparatus is provided to furnish accurate continuous records of the flow of sewage, as an aid in the intelligent operation of the plant. This meter is set in a concrete vault below the surface of the ground, where the up-stream and down-stream piezometer rings are accessible at all times for inspection and cleaning. Pipe connections extend to float wells in the laboratory building, where the recording apparatus is located.

Imhoff Tanks.—There are five rectangular Imhoff tanks, each 30 ft. wide by 90 ft. long inside. The tanks (Fig. 2) are designed to have a sedimentation period of 3 hours. The quantity of sludge provided for is 1.26 cub. ft. *per capita*, which is equivalent to about 0.007 cub. ft. per day for a period of six months. In addition, considerable space is allowed for the accumulation of scum and for the moderately clear water between the sludge and scum. The total working* capacity of the Imhoff tank is equivalent to 4.59 cub. ft. *per capita*. The tanks have vertical side walls, 18 ft. 5 in. in depth, below which the bottoms of the tanks are constructed in the form of inverted pyramids, 7 ft. 6 in. deep, three pyramids to each tank, making a maximum depth of 25 ft. 11 in. below the top. Each of the five tanks is divided into two compartments—a sedimentation compartment and a sludge storage compartment, by means of a cement-plaster partition wall, running longitudinally through the tank and forming three troughs in the width of each tank. The bottom of each trough terminates in a slot which allows solids settling out of the sewage, to pass through into the sludge storage compartment below, and is trapped to prevent the escape of gas. Gas resulting from sludge digestion escapes by central and side gas vents, instead of passing up through the sewage flowing in the sedimentation compartment.

Each of the three hoppers in the sludge compartment of each Imhoff tank is provided with an air lift for removing the sludge. The advantage of this apparatus over the centrifugal or reciprocating pump is that the sludge is not broken up in its passage through the apparatus and the entrained gases are not liberated. If they were, the sludge would dry more slowly because it would be less porous. Compressed air is forced into the main riser pipe through a small air pipe entering at the side near the bottom. The compressed air accumulates until the specific gravity of the sludge contained in the pipe is decreased to a point below that of the liquid in the tank when the mass begins to rise. As the air approaches the surface it expands, due to the decrease in pressure, and the vertical velocity becomes greater, causing a continuous flow of sludge from the top of the pipe. This flow is maintained as long as the supply of air is maintained, and the sewage in the tank is not drawn down below a critical point. This form of air lift is used extensively for pumping water, especially for irrigating purposes, but its use for lifting sludge is comparatively recent. From tests made on the air lift at the Fitchburg plant it appears that where dense masses of sludge are encountered which are too heavy to be lifted in the above-mentioned manner, the compressed air accumulates for a time, forcing pistons underneath succeeding masses, finally pushing them up and discharging them intermittently into the pipe line at the top. At Fitchburg, under normal operating conditions, the lift from the surface of the sewage in the Imhoff tanks to the flow-line in the sludge pipe at the top of the vertical pipe is 8½ ft.

Sludge Beds.—Open sand beds are provided for drying the sludge. They are in units 15 ft. wide by 111 ft. long, separated by partitions constructed of 2-in. creosoted planks 12 in. wide, set on edge and held in grooves in concrete posts. Each bed is served by a narrow-gauge track laid on the surface of the sand

* Paper (somewhat abbreviated) read before the Western Society of Engineers.

† Of Metcalf and Eddy, Boston and Chicago.

* From surface of sewage to bottom of tank.

along the centre line of the bed, with switches and a main track at the end of the beds leading to the sludge dump. The sludge, when sufficiently dry, is forked into the sludge dump, making it unnecessary to drive teams on to the sludge beds. This prevents injury to the beds, caused by teaming over them. The total area of sludge beds is 18,340 sq. ft., or 0.33 sq. ft. *per capita*. No under-drains were provided at Fitchburg, as the beds were built in a gravel deposit high above the ground water. However, the estimates given herein include an under-drain pipe laid longitudinally in the centre of each bed leading to a collector drain across the ends of the beds, as drains are likely to be required under many conditions.

Dosing Tanks.—The sewage after leaving the Imhoff tanks flows alternately into one or the other of two dosing tanks, each having a unit working capacity of 0.175 cub. ft. *per capita*. Each dosing tank is provided with automatic siphonic apparatus arranged to discharge the contents of the tanks alternately into the distribution system of the trickling filters. The dosing tanks are constructed so as to vary the volume discharged at the several heads and produce a substantially uniform distribution of the sewage over the surface of the trickling filters.

Trickling Filters.—The trickling filters (Fig. 3) have been designed to serve 20,000 persons per acre, with the stone at least 10 ft. deep. Sewage is conveyed to the trickling filter from the dosing tanks, through a cast-iron pipe distribution system, and sprayed on to the surface of the stones through nozzles placed at the apices of equilateral triangles having sides 15 ft. long. The maximum head on the spray nozzles is 8 ft., which is gradually reduced to a minimum of about 1 ft. in order thoroughly to distribute the sewage.

The crushed stone, which is between 1 in. and 2 in. in size, rests on a draining floor system of the type shown by Fig. 3. The concrete floor is constructed in the form of circular channels sloping toward the main drains. The channels are covered by rectangular slabs of cement mortar, laid on edge about 1 in. apart, so as to form a grating through which the sewage passes after trickling down through the stones. A flushing and inspection gallery is provided in the centre of the filter, for use in cleaning out deposits of sand or humus, if any accumulate in the channels of the floor system.

The stone at the sides of the trickling filter is prevented from mixing with the gravel beyond by thin partition walls constructed of cement plaster on metal lath. The partition is constructed on a slope, thus providing a greater area at the surface of the filter than at the bottom, so as to catch the outer portion of the spray from the filter nozzles.

Secondary Settling Tanks.—The typical trickling-filter plant upon which the accompanying estimates are based (Figs. 4 and 6) includes four sedimentation or humus tanks, each cylindrical in form, 30 ft. in inside diameter, with a conical bottom. The total depth to the bottom of the inverted cone is 24 ft., the depth of the vertical side walls being 14 ft. 9 in. The aggregate working capacity is about 360,000 gallons, equivalent to 0.85 cub. ft. *per capita*. The tanks are designed to furnish a sedimentation period of 1 hour, and to have a sludge capacity of approximately 0.15 cub. ft. *per capita*. They are of the vertical-flow type. The water passes into a central distributing cylinder in each tank, thence downward and underneath its bottom edge, thence upward to and out over a number of weirs located around the side of the tank. The sludge accumulating in the bottoms of the tanks is regularly lifted, by a centrifugal pump, into the influent channel to the Imhoff tanks. Here the solids settle with the suspended matter of the raw sewage and pass into the sludge compartments, where they are subjected to bacterial action, to render them inoffensive.

Miscellaneous.—In addition to the main features of the trickling-filter plant there have also been provided a suitable pumping equipment and building, air lifts for the sludge, air-compressing equipment, a laboratory building suitable for housing the office, laboratories, store rooms and locker rooms for the men employed about the plant; also roads, water supply, electric light and other features necessary to make the plant complete and ready for operation.

Activated Sludge Plant.

The plant for the activated sludge process has been designed as far as possible to meet the same conditions as those for which the trickling-filter plant previously described was built. The same type of structures has been used where applicable, and an effort has been made in every way to make the two plants strictly comparable, both being designed to serve 55,000 persons.

Grit Chamber, Screens and Venturi Meter.—The grit chamber, screens and venturi meter equipment previously described for the trickling-filter plant is included without change in the activated sludge plant, the requirements being the same in each case.

Sewage Aeration Tanks.—The sewage aeration tanks have been designed on the continuous-flow plan. The tanks are rectangular in plan (Figs. 7 and 8 overleaf), each unit being 30 ft. wide by 90 ft. long inside, of a type similar to the Imhoff tanks in the trickling-filter plant. Compressed air is supplied to the tanks through a piping system leading to a series of filtros blocks located in the bottom of the tank. Each tank unit is divided by means of thin partition walls into four longitudinal channels, 7 ft. 2 in. wide. Provision is made for a depth of 10 ft. of liquid above the top of the filtros blocks. It is intended to operate two tank units in series and five double tank units in parallel; that is, the sewage will enter one tank, pass longitudinally back and forth through the four channels in that tank, then to the second tank, and back and forth longitudinally through the four channels of that tank to the point of discharge, making a total distance travelled of about 700 ft. Sufficient tank capacity is provided for an average period of aeration of 4½ hours, with sludge capacity amounting to 25 per cent. of the total tank capacity. Under these conditions the average horizontal velocity will be about 2.6 ft. per minute. The ratio of total tank floor surface to area of aerating system is 8.5 to 1, which is the basis of the present Milwaukee tanks. The indications are, however, that this ratio should be reduced so as to provide a somewhat larger area for air diffusion.

For the purpose of aeration and agitation it is assumed that the volume of air to be supplied will average 1.75 cub. ft. per gallon of sewage treated.

Air Compressors.—The quantity of air required to aerate the average quantity of sewage at the rate of 1.75 cub. ft. per gallon treated will be 6,680 cub. ft. per minute. An increase in rate of sewage flow to 150 per cent. of the average will frequently occur, and the air-compressing plant must be able at all times to meet this requirement. In addition, provision must be made for emergencies of various kinds. For this service four units of electric, motor-driven, positive-pressure blowers are provided, each capable of furnishing about 3,200 cub. ft. of free air per minute at a pressure of about 5 lb. per square inch. The motors must be of the variable-speed type, in order that the quantity of air may be varied according to the requirements. Two additional blowers of the same type and size are provided, to furnish air for the sludge aeration tanks.

There are three types of air compressors available for service of this character—the positive-pressure blower

Fig. 3. TYPICAL SECTION OF TRICKLING FILTER.

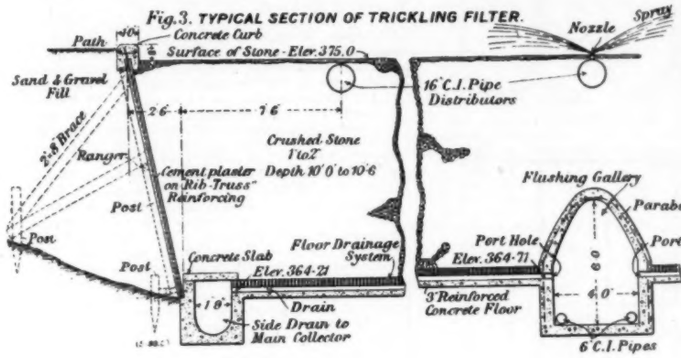


Fig. 4. TYPICAL CROSS SECTION OF SECONDARY SETTLING TANK.

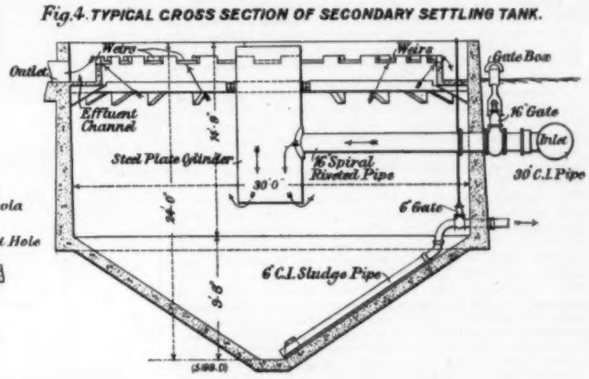


Fig. 5. PLAN OF TYPICAL ACTIVATED SLUDGE PLANT FOR SEWAGE TREATMENT.

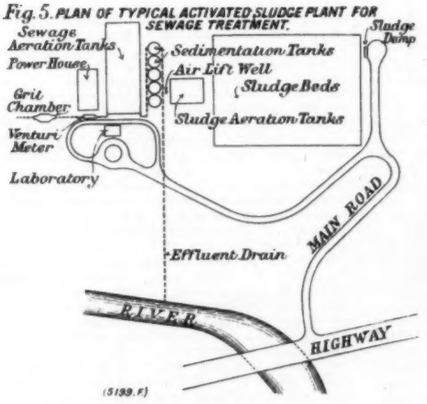


FIG. 6.

compressors. One disadvantage of the reciprocating compressor is that the air discharged may contain oil, which is liable to cause clogging in the filtros blocks or other air diffusers. The internal parts of the positive-pressure blower and centrifugal compressors do not require lubrication, so that the air discharged from these machines should be free from oil.

Air Washer.—On account of the small pores in the diffusing system (Fig. 7), whether filtros or wooden blocks or other means are employed, it is essential that the air furnished shall be clean, that is, free from dust, oil or other foreign substances. One of the best methods of obtaining clean air is to pass it through an air washer before going to the compressor. Such apparatus is a standard commercial product and operates satisfactorily.

Measurement of Air Volume.—It is essential to know the quantity of air supplied to the diffusing system if the plant is to be operated most intelligently. Several forms of air measuring apparatus are available. The estimates provide for two air-flow meters of the General Electric Company type, similar to those in use at the Milwaukee plant. One of these meters is intended to measure the quantity of air supplied to the sewage aeration tanks, and the other the air supplied to the sludge aeration tanks. In a large plant it may be advisable to install additional meters to measure the quantity of air supplied to air lifts, but in this comparison no allowance is made for such additional apparatus.

Power-house.—A building will be required to house the several air-compressor units, amounting, in this particular case, to six large positive-pressure blower units and two small reciprocating units for operating the air lifts. This building may also house the air washer, air meters, transformers and other equipment.

Sedimentation Tanks.—The effluent from the sewage aeration tanks will contain a large quantity of suspended matter, which must be removed by sedimentation. The estimates include six sedimentation tanks. Each is of the vertical-flow type, cylindrical in form, with inverted conical hopper bottom terminating in a deep well 4 ft. in diameter, similar to the tanks at Milwaukee. The tanks provide for sedimentation for a period of half an hour, on the continuous-flow plan, with space for sludge amounting to 25 per cent. of the total tank capacity. The total depth of water and sludge, in the central wall, is 35 ft. The tanks at Milwaukee were constructed with hopper bottoms on a slope of 1 to 1, but experience has proved that steeper slopes are necessary if the sludge is to slide easily into the central well. These tanks are so designed that the sewage and sludge will enter the tank at the centre, flow downward and under the edge of the distributing cylinder, and thence upward and out through collecting weirs arranged around the circumference of the tank. Each of the central sludge wells will be provided with an air lift to raise the sludge from the sedimentation tanks to the sludge aeration tanks, or into the influent of the sewage aeration tanks.

Sludge Aeration Tanks.—Two units of sludge aeration tanks are provided, of a type similar to the sewage aeration tanks, but differing in that the partition walls are made heavy enough to withstand water pressure, thereby making each channel a separate sub-unit. The general dimensions of channels are the same as in the aeration tanks; that is, 7 ft. 2 in. wide and 90 ft. long, provision being made for a depth of 10 ft. The total capacity of sludge aeration tanks provided is 328,000 gallons, which is equivalent to 0.8 cub. ft. *per capita*, or about 60,000 gallons per 1,000,000 gallons of operating capacity.

Air-lift Pumps.—It is planned to provide one such lift in a well to serve the eight sub-units of sludge aeration tanks, and a similar lift for each of the sedimentation tanks. As already stated, these pumps have the advantage of handling the sludge without breaking up the flocculent particles, which is necessary to the success of the activated sludge process.

Sludge Beds.—It is estimated that the activated sludge process will produce about 4,500 gallons of sludge per 1,000,000 gallons of sewage. Doubtless this quantity will vary considerably under different conditions. It is largely dependent upon the proportion of water contained in the sludge. For the average quantity of sewage for which this plant is designed, 5,500,000 gallons per 24 hours, the quantity of sludge produced daily will be 24,750 gallons. For the purposes of this comparison it is assumed that the sludge will be dried on sand drying beds, from which it can be removed to a dump.

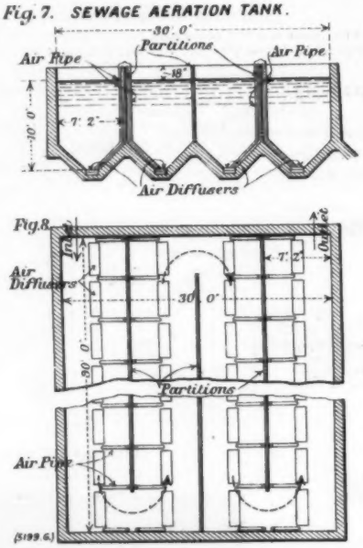
It is recognised that important experimental work is being done to develop suitable de-watering and drying processes that will make it economically possible to dry the sludge to 10 per cent. moisture and thus make it saleable as a low-grade fertiliser or as fertiliser base. Analyses reported by William R. Copeland, chief chemist of the Milwaukee Sewerage Commission, in a recent paper before the American Chemical Society, indicate that activated sludge contains a much higher percentage of nitrogen than the sludge from other processes such as plain sedimentation, chemical precipitation, the septic tank and the Imhoff tank. The preparation of this material for fertiliser is still in the experimental stage, and it is too early to make positive assertion regarding the cost of this work. There are, however, some promising indications, and it may be that the disposal of sludge may become a self-supporting part of the process, or even produce a revenue which will help to pay the cost of other portions of the plant.

For the purpose of estimates it is assumed that the sludge drying beds can be dosed an average of 15 times per year to a depth of 12 in., thus requiring a total net area of sludge beds of 80,500 sq. ft. To this should be added a sufficient area to care for sludge during the winter months (December 15 to March 15) and to allow for drawing of water collecting on the surface of the sludge. To provide for these contingencies the area should be increased 50 per cent. to 120,750 sq. ft., equivalent to 2.76 acres net area, or 2.2 sq. ft. *per capita*. If sludge bed units of the same size and type as described for the trickling-filter plant are used, there will be required 77 such units, or about seven times the area required for the trickling-filter process. These sludge beds are suitably underdrained and provided with a system of narrow-gauge tracks and cars for removing the sludge to the sludge dump, when it can be carted to a point of disposal.

Cost of Construction.

The cost of the trickling-filter plant, as already stated, has been based on the unit costs of construction of the trickling-filter plant at Fitchburg, Mass., which was built by contract, bids being received in May, 1913. Cost figures obtained in this way are more nearly representative of normal conditions than if based on the high cost of construction prevailing at the present time. As far as possible the same unit costs of construction have been applied to the estimates of the activated sludge plant, that the two estimates may be comparable.

Fig. 7. SEWAGE AERATION TANK.



Trickling-Filter Plant.—The estimated cost of the trickling-filter plant is given in Table 1. In addition to the main features already described, a number of items are included which go to make up the complete plant. It should be noted that the amount included for cost

TABLE 1.—*Estimated Cost of Imhoff Tank-Trickling Filter Plant.*

—	Cost, Excluding Engineering and Administration. Total.	Unit Cost, excluding Engineering and Administration. *Per Capita.*	Per 1,000,000 Gallons per Day.
	Dols.	Dols.	Dols.
Grit chamber and screen ..	10,000	0.18	1,818
Venturi meter chamber	3,000	0.05	545
Imhoff tanks, including air lifts for sludge	64,500	1.17	11,720
Air compression equipment ..	800	0.01	145
Sludge beds, including underdrains	4,800	0.09	873
Trickling filters, 10 ft. deep (2.75 acres)	188,500	3.43	34,300
Dosing tanks and apparatus ..	16,600	0.30	3,020
Secondary settling tanks ..	9,000	0.16	1,637
Sludge pumping equipment and building	2,000	0.04	364
Conduits and pipe lines, including overflow	10,600	0.19	1,925
Effluent channel	1,300	0.02	236
Roadways	9,100	0.17	1,655
Laboratory building and equipment	15,200	0.28	2,762
Grounds, trees, planting, &c. ..	1,700	0.03	309
Miscellaneous work, 4 per cent. of total, excluding land	13,300	0.24	2,420
Land	25,000	0.45	4,550
Total	375,400	6.81	68,279
Add 15 per cent. for engineering and administration ..	56,310	1.04	10,221
Grand total	431,710	7.85	78,500

For 55,000 persons = 7.85 dols. *per capita*.
For 5,500,000 gallons per day = 78,500 dols. per 1,000,000 gallons per day

of land includes not only the land required for the treatment plant, but a total area of about 117 acres, sufficient not only for all purposes of sewage treatment, but also more than sufficient properly to isolate the plant. Under miscellaneous work are included such items as extension of the water supply, electric lighting system, and other features of minor importance not covered by the principal items. It is expected that for a plant of this character administration charges may easily amount to 3 per cent. and engineering to 12 per cent., making a total of 15 per cent. to be added for these items. The total estimate of the Imhoff tank-trickling filter plant for a city of 55,000 population is 431,710 dols. This is equivalent to 7.85 dols. *per capita*, or 78,500 dols. per 1,000,000 gallons per day for the assumed flow of 5,500,000 gallons.

(To be continued.)

COST OF MATERIALS IN THE UNITED STATES.—We read in *The Iron Trade Review*, Cleveland, Ohio, that in connection with the recent announcement to the effect that the Westinghouse Electric and Manufacturing Company will arrange for 15,000,000 dols. additional funds, an analysis of the cost of materials used by the company has been prepared by Clark, Childs and Co., New York. The analysis demonstrates that 14 of the principal products used by the company have advanced by an average of 314 per cent. in 2½ years, the largest single advance being an increase of 942 per cent. in the cost of plates used for frames. Increases in sheet steel extended from 153 per cent. to 443 per cent.; coke, 522 per cent.; malleable iron castings, 202 per cent.; and wages, 50 per cent.

UNITED STATES STEEL OUTPUT.—Returns from a large part of the steel-producing capacity of the United States indicate, says *The Iron Age*, that the output of steel ingots in the first half of this year was close upon 21,475,000 gross tons, or at a rate of 42,950,000 tons a year. In 1916, according to the official statistics, the American production of ingots was 41,401,000 tons. As pig-iron production in the first half of this year was 350,000 tons less than in the first half of 1916 and 550,000 tons less than in the second half, the increased production of steel must have been due to one of two things, or both; namely, a larger use of scrap in the making of open-hearth steel and the use of a considerable tonnage of cold pig-iron drawn from stocks. It is probable that both of these things happened. The larger buying of scrap by steel works is quite well established; it is known also that stocks of pig-iron were, roundly, a half million tons less on July 1, 1917 than one year previous. At all events the larger output of steel in the first half of this year, and the continuance of this higher rate through July, with some further increase, are of interest as bearing on the future values of steel.

TESTS FOR TUNGSTEN ORES.—A qualitative reduction test for tungsten is as follows: Not less than 0.2 gramme of finely divided material is boiled in a small test tube with concentrated hydrochloric acid until about one-half of the acid is evaporated. A fine blue colour in the solution or a blue residue indicates the presence of tungsten. Should this test give negative results, about 0.5 gramme of the material should be fused in at least 4 grammes of sodium carbonate, which may be done with an ordinary Bunsen burner in a metal crucible, or before the blast in a porcelain crucible. The fused mass is dissolved by boiling water in the crucible; the aqueous solution is then acidified with an equal volume of concentrated hydrochloric acid. A piece of metallic tin is added, and the solution warmed if necessary. The volume of the solution should not be greater than 10 c.c. to 20 c.c. A fine blue colour in the solution or a blue residue indicates the presence of tungsten. In either case, should the reduction be continued long enough, a brown colour is obtained. These tests, if properly used, should show the presence of tungsten in materials containing as little as 2 per cent. Special precautions may enable the presence of tungsten to be detected in even lower-grade materials. Niobium is the only element at all likely to give a blue colour under the conditions of this test, but the blue can be distinguished from that of tungsten oxides by the fact that it disappears when the blue solution is diluted with water. Vanadium also gives a blue colour when solutions of its salts are reduced, but tartaric acid will cause this reduction also, whereas it will not reduce tungstic acid. Molybdenum, on reduction, goes through a series of colour changes from violet to blue, and then to black; titanium gives a violet colour; no other elements will ordinarily interfere with the test for tungsten. The methods in most ordinary use for the quantitative determination of tungsten in ores are the hydrofluoric acid method, the fusion method, and the aqua regia method. An occasional assay method is as follows: When tungsten is in solution in the condition of tungstate it is possible to precipitate and estimate it in the form of the trioxide WO_3. To effect this all that is needed is to render the solution acidic by means of hydrochloric, nitric or sulphuric acid. Tungstic acid is soluble to some extent in mineral acids. A method of determining tungsten is based on the precipitation of tungstic acid by an excess of a solution of freshly prepared stannous chloride, which precipitates the tungsten from solution in the form of the tungsten oxide W_2O_5. A useful tungsten determination is as follows: After decomposing the ore the tungsten may be determined by dissolving the tungstic acid in weak ammonia, and thus separating it from the silica and other insoluble matter. If a little hydrochloric acid be added to the dilute ammonia used for dissolving and washing, a small quantity of ammonium chloride is formed, which prevents silica running through the filter paper with the dissolved tungstic acid. Some silica may pass into the filtrate when washed with ammonia alone, and so cause high results unless subsequently removed with hydrofluoric acid.

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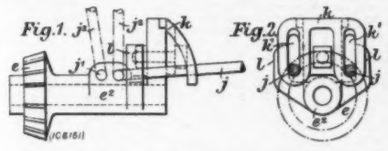
AGRICULTURAL APPLIANCES.

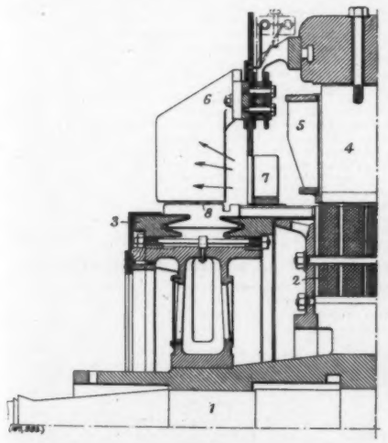
108,061. G. M. Blackstone and H. V. Blackstone (*Legal representatives of the late F. C. Blackstone*), **and R. E. Watts, Stamford. Swath Turners.** (3 *Figs.*) August 30, 1916.—This invention relates to means for mounting the tines in swath turners of the kind in which the turning devices are fitted with a series of tines or forks arranged concwise round their axis of rotation. According to this invention, the tines are pivoted separately in any suitable manner to the carrying members, which may be the bosses of epicycle bevel wheels. Slotted guides are arranged on the carrying members to limit the pivotal motion of the tines, which are preferably so shaped in conjunction with their carriers that, on removing the guide and turning the tines into an inoperative position, they are free to be withdrawn from



their carriers. *e* is the planet pinion and *e*2 is a boss or carrier, which may be integral with it. *j*, *j* are the tines, having their inner ends bent at right angles to form pivots carried in the holes *j*1, *j*1 in the boss *e*2. *k* is a guide member having formed in it two slots *k*1, *k*1, in which the tines are independently free to rise and fall to an extent limited by the length of the slots, so that their outer ends or points may be enabled to follow the configuration of the ground over which they pass. *l*, *l* are lugs formed on the boss *e*2 to retain the tines in position laterally. The member *k* is secured to the boss *e*2 by means of a bolt, and is kept from twisting by lugs. The tines can be removed, by detaching the guide-piece *k* and sliding it off the tines, when they can be turned to the positions shown at *j*2, *j*2 and withdrawn from their pivot holes. (*Accepted August* 1, 1917.)

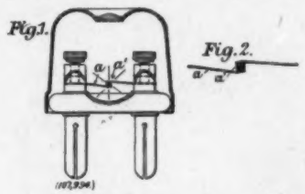
ELECTRICAL APPARATUS.

107,993. The British Thomson-Houston Company, Limited, London, and F. P. Whitaker, Rugby. Dynamo-Electric Machines. (1 *Fig.*) April 20, 1916.—The invention relates to high-voltage direct-current generators and rotary converters having axial commutators. The invention provides an improved method of preventing flash-overs, and to this end it consists in forcing a strong blast of air through the spaces between sets of commutator brushes away from the machine, so as to prevent the formation of, or to disrupt, a conducting metallic vapour path between the brushes. This blast may be conveniently produced by a fan fitted to the armature between the



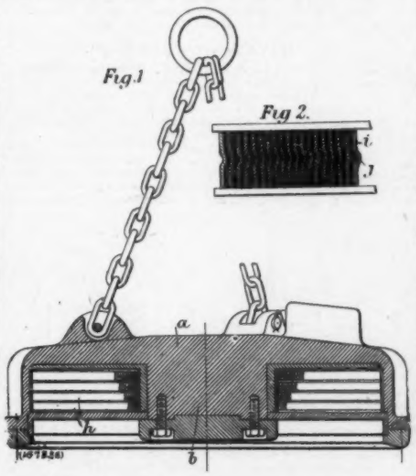
armature core and the commutator, so that a strong blast of air is driven over the surface of the commutator between the brush arms away from the machine. 1 is the armature shaft, on which is mounted the armature core 2 and the commutator structure 3. 4 is a field magnet, carrying a field core 5. 6 is a brush-holder arm, and 7 is an impeller fan mounted between the armature core and the commutator, and adapted to force a strong blast of air over the working surface 8 of the commutator between the sets of commutator brushes, in the direction shown by the arrows. This blast prevents the accumulation of conducting material in the space between brushes of opposite potential and thus avoids "flash-overs." (*Accepted August* 1, 1917.)

107,994. A. F. Berry, Ealing. Electric Fuses. (11 *Figs.*) April 20, 1916.—This invention has reference to electric fuses designed to serve as current indicators. An indicator fuse, according to the invention, is so constructed that when in ordinary use a portion thereof intermediate of its ends is caused to become luminous by the current passing therethrough, whilst its end portions, for connection to terminals, remain cooler and relatively non-luminous. For this purpose resistance wire or strip *a* made of small gauge, and of a metal or alloy, such, for example, as nickel-chromium alloy, that is not readily fusible, and which, when heated to redness by an electric current, becomes coated with a protective insulating film of oxide, is so wound, bent or otherwise formed as to constitute one or more concen-



trated or localised intermediate portions *a*1, in which heat, due to the passage of an electric current of predetermined safe value therethrough, is allowed to develop sufficiently to cause it or them to become luminous or glow, whilst the remaining portions of the fuse are left sufficiently cool to prevent them becoming red hot and luminous. To assist in the production of a glowing heat in the concentrated portion or portions *a*1, such portion, or each of them when two or more are provided, may, when in use, be shielded to a greater or less extent against the cooling action of surrounding air, as by shielding means on the fuse, or the fuse block or carrier, whilst the remaining portions of the fuses are left freely exposed to the cooling action of air so as to be prevented from becoming luminous. (*Accepted August* 1, 1917.)

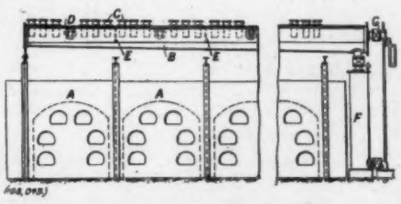
107,856. A. West, Brighton, and Allen West and Co., Limited, Brighton. Electric Lifting Magnets. (2 *Figs.*) August 10, 1916.—This invention relates to electric lifting magnets, such as are employed in hoisting and traversing cranes, travellers and the like. The invention consists broadly in providing the energising coil with a corrugation, corrugations or equivalent means whereby the distortion of the coil when wound about its core is prevented. According to one form of the invention, the energising coils A are formed in one or more



sections disposed concentrically within the magnet casing *a*, each section being composed of alternate windings of copper strip *i* and insulating medium provided with a central corrugation *j* parallel to the edges of the strip whereby the windings are caused to interlock. Coils made up in this manner when packed closely within an annular space formed by the outer walls of the magnet casing and a central core *b* formed therein have been found to increase greatly the lifting capacity of the magnet. (*Accepted July* 25, 1917.)

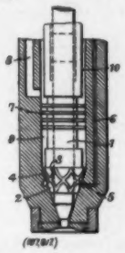
GAS ENGINES, PRODUCERS, HOLDERS, &c.

108,049. H. E. Bloor, York, and J. B. Fenwick, Heworth, York. Hydraulic Mains. (4 *Figs.*) August 15, 1916.—This invention relates to hydraulic mains as used in connection with gas retorts and other carbonising plant. In hydraulic mains, according to this invention, the main is sloped or inclined towards one end, whereby the tar produced in any number of settings may be directly and effectually drawn off as produced without the use



of a separate tar main. Further in accordance with this invention, division plates sealing into the tar and liquor in the main (between the settings) are employed, whereby settings as a whole may be left uncharged and whereby gas cannot in any circumstances pass from those sections of the main which are in use to those which are out of commission. A are the retort settings, and B the continuous inclined hydraulic main having the usual dip pipes C and gas off-takes D. In order to permit of any one or more of the settings A remaining out of action whilst the others are working, the main B is provided with vertical division plates E forming a joint with the cover and sides of the main, but not extending to the bottom of the main, an ample space being left for the flow of tar. The main B extends over the tar tower F, so that the tar draws directly into the tower. In order to regulate the depth of liquor in the hydraulic main B, a weir valve G is provided on the end of the main and is operated in the usual manner. The main B is preferably provided with loose side seal covers H, or with otherwise open sides to facilitate inspection and cleaning. The continuous inclined hydraulic main combines the following advantages, viz.: no separate tar mains or branches are required; regular flow of tar as produced; any setting or settings can remain idle; no stoppages of the ascension pipes; no clogging up of the hydraulic main; the retention of a liquor seal to the dip pipes and the ready means of inspection of the hydraulic main without any interruption in the working of the plant. (*Accepted August* 1, 1917.)

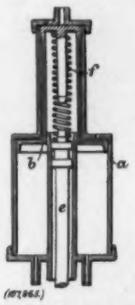
107,817. Willans and Robinson, Limited, Rugby, and J. M. Ferguson, Rugby. Internal-Combustion Engines. (2 *Figs.*) July 13, 1916. This invention has reference to the injection of fuel into the cylinders of internal-combustion engines of the kind in which the fuel is introduced at the end of the compression stroke, and is ignited by the high temperature of the air compressed in the cylinder. The object of the invention is to provide an improved arrangement for separately pulverising the pilot charge adjacent to the point of introduction to the cylinder to the ends of obtaining a more efficient atomisation of the ignition fuel and of effecting economy in the use of the lighter fuel employed for this purpose. The fuel valve 1 is provided with a pulverising cone 2, having a plurality of spiral grooves 3. The corresponding conical portion 4 of the fuel-valve



chamber is formed with a circumferential groove 5 adjacent the points where the spiral grooves 3 intersect. The groove 5 is in communication with a duct 6 for introducing the pilot charge, and the usual pulverising rings 7 for the heavier fuel—which is introduced through the duct 8—for normal working of the engine, are arranged at an appropriate distance above the cone 2, so that a chamber 9 is formed to contain the requisite amount of injection air introduced through the passage 10 to satisfactorily atomise the pilot charge. With the arrangement described, considerable disturbance of the injection air will be caused at those points where the grooves 3 in the cone 2 intersect, and as such disturbance takes place in immediate proximity to the groove 5 receiving the pilot charge, a very efficient pulverisation of said charge will be obtained. (*Accepted July* 25, 1917.)

GUNS AND EXPLOSIVES.

107,865. The Whitehead Torpedo Works (Weymouth), Limited, and H. W. Ridsdale, Weymouth. Automobile Torpedoes. (9 *Figs.*) August 31, 1916.—The invention relates to means for delivering lubricant to the bearings of the motors of automobile torpedoes. According to this invention, apparatus is provided which is actuated by the fluid pressure and is so constructed and arranged that at the commencement of the run of the engine or motor the bearings will be instantly flooded by the lubricant, the subsequent rate of delivery being dependent upon the pressure of the fluid and the speed of the engine or motor. For this purpose it is preferred to construct the lubricant reservoir in the form of a cylinder *a* and to displace its contents by the stroke of a fluid-pressure-actuated piston *b*, the movement of the piston being controlled by two devices acting in conjunction with each other. The first device comprises a control member *e* connected with the engine shaft, by a train of gear wheels or otherwise, in such a manner that each

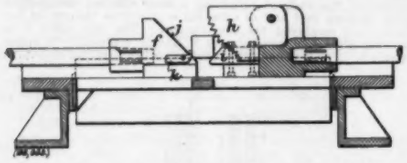


revolution of the engine shaft shall correspond to a fraction of the stroke of the control member. This device alone will not, however, attain the object, because if the engine shaft and piston be positively connected, the volume of lubricant delivered would be constant per revolution of the engine. Resort is therefore made to another device for causing a maximum rate of delivery at starting, which device comprises a spring *f* interposed at some point between the piston *b* and the control member *e*, the said spring acting in the opposite direction to that of the fluid pressure. The spring is so arranged as to be more or less in equilibrium before admission of the fluid, and offers only slight resistance at first to the fluid pressure, so that it is easily extended, compressed or otherwise energised in accordance with the type of spring employed. The piston is therefore at first acted on almost freely by the fluid pressure, and is practically uncontrolled by the control member operated by the engine shaft, thus delivering lubricant at a rapid rate. As the spring becomes more completely extended, compressed or otherwise

energised, the rate of movement of the piston will become more fully controlled by the engine shaft, until, towards the end of the piston stroke, the spring will act almost or entirely as a rigid part of the connection between the piston and the engine shaft. The spring further provides a means of delivering lubricant in greater volume per revolution of the engine shaft when the power developed is relatively higher. It is known that at the higher engine powers used in short runs the propelling fluid is admitted to the engine at higher pressures. By using the pressure of this fluid to actuate the piston, the fluid will, at the higher engine powers, exert a relatively greater force in opposition to the spring, and the piston will therefore reach the end of its stroke earlier (the time corresponding approximately to the shorter lapse of time involved in short high-speed runs), and will have caused the full contents of the lubricant reservoir to be utilised, notwithstanding the substantially smaller total number of revolutions of the engine shaft. (*Accepted July* 25, 1917.)

MINING, METALLURGY AND METAL WORKING.

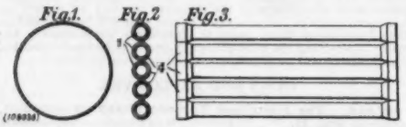
108,050. W. Williams, Gilwern, Breconshire. Ingot Manipulating Apparatus. (8 *Figs.*) August 15, 1916.—This invention relates to apparatus for turning over and manipulating ingots, blooms, billets, bars and the like in rolling mills. According to this invention, the turning head is provided with lower rigid-raw members or wedges *i* and an upper overhanging pivoted-jaw member *h* co-operating therewith to impart a turning movement to the work about the longitudinal axis thereof, the other head *f* being held stationary during the initial



part of the turning movement and serving as an abutment, for the work. By this means a bar, for example, of rectangular section, may be turned on one edge and guided to the rolls in that position, or by drawing back the abutment head *f* and further advancing the other head a turning of the bar through an angle of 90 deg. may be effected. The abutment head *f* is so shaped that it presents an upwardly-inclined face *j* to the work, and may be provided with adjustable toothed or serrated-cheek portions or pivoted fingers *k* intended to prevent the work from sliding up the said inclined face of the head. (*Accepted August* 1, 1917.)

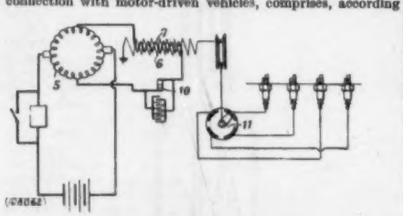
MOTOR ROAD VEHICLES.

108,036. J. Edwards, Erdington, Birmingham, H. S. Mattey, Streetley, Warwickshire, and Speedwell Gear Case Company, Limited, Birmingham. Radiators. (5 *Figs.*) July 26, 1916.—The invention refers to that class of radiators which consist of a number of horizontal, or substantially horizontal, tubes through which air may pass, the tubes being slightly separated from each other to provide a water-circulating space between them. According to this invention,



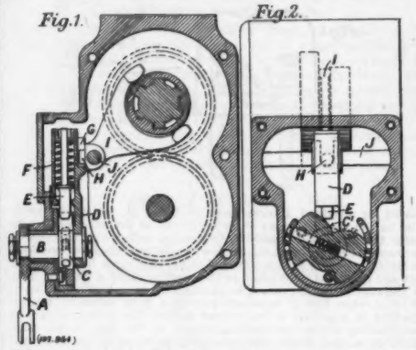
a radiator is built of a series of tubular members of large diameter (Fig. 1), which are rolled or pressed so as to produce from the one large tube a member having the appearance of a plurality of parallel small tubes 1 (Fig. 2), and having their extremities 4 enlarged or otherwise formed so that whilst said extremities contact with each other the greater part of their surfaces is separated to provide a water-circulating space. (*Accepted August* 1, 1917.)

108,062. W. Holt, Wylde Green, Birmingham, and B. Brooks, Birmingham. Combined Electric Lighting and Ignition Dynamos. (5 *Figs.*) September 5, 1916.—This invention relates to dynamo-electric machines for use in conjunction with accumulators upon motor-driven vehicles for the double purpose of electric lighting and for providing the current for the ignition system of the engine. A dynamo-electric machine for combined electric lighting and ignition, in connection with motor-driven vehicles, comprises, according



to this invention, the combination with a lighting dynamo of a transformer coil 6 mounted upon the armature shaft, or upon a shaft driven therefrom, so as to rotate therewith, and whose primary winding 7 is connected to the armature 5 of the dynamo so as to tap off therefrom an alternating current, which is utilised for the excitation of said primary winding, a contact-breaker 10 being provided in the primary circuit, and a distributor 11 for the high-tension current, the whole forming a self-contained unit. (*Accepted August* 1, 1917.)

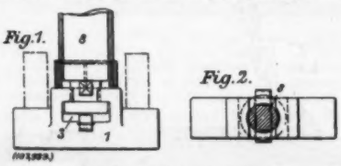
107,954. Triumph Cycle Company, Limited, and G. E. Stanley, Coventry. Change-Speed Gears. (2 *Figs.*) May 5, 1917.—This invention relates to change-speed gears of the kind in which the gear wheels are engaged by a sliding fork, which is caused to slide in the direction in which the gear wheels are to be moved by a change-speed lever, which is rocked on its pivot when it is desired to change the speed. In gears of this type it is sometimes difficult to disengage the gear wheels and engage for the next speed when under load, and the exercise of excessive force upon the change-speed lever results in damage to the mechanism. According to this invention, a yielding device is interposed, and the apparatus comprises the combination of a change-speed arm loosely mounted on a spindle, cam surfaces rigid on the spindle, a spring-pressed plunger mounted on the arm so as to operatively engage the cam surfaces, and means to rotate the spindle. A change-speed lever A is rigidly connected to a spindle B, on which is provided a cam C having two cam surfaces C1. Loosely pivoted on the spindle B is a change-speed arm D provided with a plunger E pressed into engagement with the cam surfaces C1 by a spring F. A groove G in the arm D receives an extension H of a fork I, which engages the gear wheels and is slidably mounted on a spindle J. When it is desired to effect a change of speed the lever A is rocked through the necessary angle, the spindle B is correspondingly rotated, and



with it the cam C. If the gear wheels can disengage freely the arm D will be caused to rock on the spindle B and will slide the fork I along the spindle J, thereby moving the gear wheels through the desired distance. If, however, the gear wheels do not disengage freely (owing to their being under load or for any other reason) the fork I will be unable to slide along the spindle J and the arm D will not rock on the spindle B, but the plunger E will be forced backwards by the cam surfaces C1, and will compress the spring F. Thus damage to the mechanism is prevented, and as soon as the gear wheels can disengage the compressed spring F will force the plunger down the cam surface C1, the arm D will swing on its spindle, and the wheels will be moved into a position appropriate to that into which the cam has been rotated. (*Accepted July* 25, 1917.)

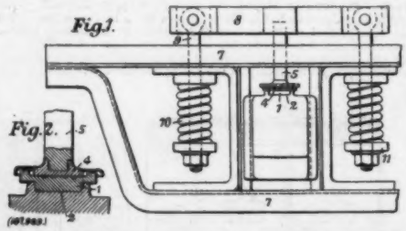
RAILWAYS AND TRAMWAYS.

107,939. E. S. Luard and V. P. Rawlings, London. Vacuum-Brake Apparatus. (9 *Figs.*) March 1, 1917.—It has heretofore been proposed to provide on the end of the piston rod of a vacuum-brake cylinder a crosshead which can swivel or turn about the end of the piston rod, so that the crosshead can be adjusted to bring its trunnions or pins in proper position or alignment to be engaged by the arms or bifurcated end of the brake-shaft lever. The invention consists principally in a construction of the crosshead and of the lower end of the brake piston rod, such that for placing and maintaining the crosshead on the end of the piston rod the crosshead is simply moved or



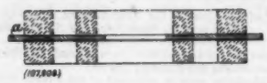
passed into engagement with the end of the piston rod, and is thus effectively connected with the piston rod, while at the same time the crosshead can be readily turned about the end of the rod for the purposes of adjustment. According to this invention, an opening or channel 3 is provided in the crosshead 1, and the end of the piston rod 3 is formed or provided with means so that the crosshead can be placed in position and maintained on the piston rod by moving the crosshead over the end of the piston rod and then moving the crosshead downwardly or releasing it and allowing it to move down, no screws or other fastening means being required for maintaining the crosshead on the piston rod. (*Accepted July* 25, 1917.)

107,989. T. F. Craddock, London (*Burn and Co., Limited, and A. Craven, Howrah, Bengal, British India*). **Railway Vehicles.** (4 *Figs.*) January 20, 1916.—This invention provides improved spring arrangements for the axle-boxes of railway vehicles. According to this invention, there is provided in connection with each axle-box a plate 1, with its underside shaped to fit in the axle-box spring seat 2, the plate 1 having a flat recess in the upper side, in which recess a flat foot 4, smaller than the



recess, is placed. With the foot 4 a pillar 5 (which may be called the load-supporting pillar) is connected, this pillar 5 extending through an opening in the top member of the frame 7, so as to be capable only of vertical movement relatively to the frame 7. On the pillar 5 rests a beam 8, from the ends of which are suspended bolts 9, passing through the frame 7. The frame 7 rests on springs 10 supported between cupped plates 11, carried upon the bolts 9. (*Accepted August* 1, 1917.)

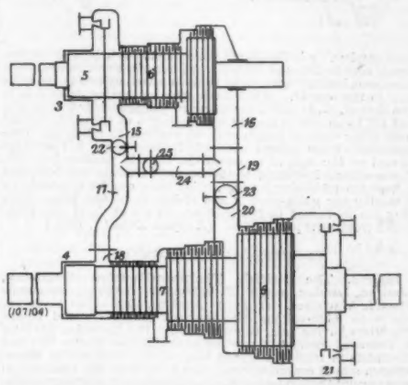
107,808. A. G. Spencer, London, and C. W. C. Hine, Dorking. Buffer Springs. (2 *Figs.*) July 11, 1916.—This invention has reference to buffer springs comprising india-rubber rings associated with metal plates. The object of the invention is to prevent the end faces of the india-rubber rings from moving relatively to the metal plates during the compression of the spring and thereby to increase the life of the spring. For this purpose, according to the invention, the surfaces of the metal plates at those parts which are in contact with the india-rubber rings are roughened, toothed or corrugated in such a way as to engage the india-rubber and prevent any sliding movement thereof



on the metal plates. The roughening may conveniently be effected by producing on the surfaces of the plates at the parts thereof stated, a number of concentric grooves, or a number of spiral threads or ridges. Such roughening is produced in any appropriate manner during the process of manufacturing the metal plates, as by cold or hot pressing, or by turning, or chasing in the case of the spiral thread formation. (*Accepted July* 25, 1917.)

SHIPS AND NAUTICAL APPLIANCES.

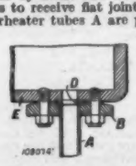
107,014. The Westinghouse Machine Company, East Pittsburgh, U.S.A. Marine Turbines. (2 *Figs.*) June 9, 1916.—This invention relates to turbine apparatus adapted to be employed in marine installations, the organised apparatus including two turbine sections 3 and 4. The section 3 includes a high-pressure element 5 and a low-pressure element or an intermediate-pressure element 6. Section 4 also includes two turbine elements 7, 8. Both of these elements are low-pressure elements. Under full power and full speed conditions fluid is delivered from the section 3 to both of the sections 7 and 8. This is accomplished by providing the section 3 with a delivery port 15, located between the elements 5 and 6, and a delivery port 16 located at the discharge end of the element 6. The port 15 communicates, through a passage 17, with an inlet port 18 of the section 4, and the port 16 communicates, through a passage 19, with an inlet port 20 of the section 4. The port 18 is so located that it delivers fluid to the inlet end of the element 7, whereas the port 20 is so located that it delivers fluid to the inlet end of the element 8. The motive fluid delivered by the element 5 is divided into two streams, one of which is delivered to the element 6 and the other to the element 7. The motive fluid issuing from the element 7 is delivered to the low-pressure element 8. This motive fluid is augmented by the motive fluid



discharged from the element 6, which is delivered to the element 8 through the port 16, the passage 19 and the port 20. All of the motive fluid is finally exhausted through an exhaust port 21 of the section 4, and may be delivered by that port to a condenser. Under reduced power and speed conditions the motive fluid is delivered in series through all of the working elements. This is accomplished by providing the passage 17 with a valve 22, the port 20 with a valve 23, and by providing a passage 24 between the port 16 of section 3 and the port 18 of section 4. This passage is provided with a valve 25, which is closed when the valves 22 and 23 are open, but which is open when the valves 22 and 23 are closed. With the valves in the positions just described, motive fluid discharged from the element 5 is delivered to the element 6, then through the port 16, the passage 24, the passage 17, and the inlet port 18, to the element 7. The fluid issuing from the element 7 is delivered to the low-pressure element 8, and is finally discharged through the exhaust port 21. As illustrated, each section 3 and 4 is capable of driving a separate driving agent. In marine installations each element will either be connected to a separate propeller or will be connected to the same propeller through a reduction gearing having separate pinions, each of which is connected to the shaft of one of the sections. (*Accepted August* 1, 1917.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

106,074. T. Sugden, London. Steam Superheaters. (12 *Figs.*) October 7, 1916.—This invention relates to an improved method of connecting the superheater tubes to the headers. This method consists in the employment of flanges fixed on the ends of the superheater tubes and adapted to be secured to the headers by studs and nuts, said flanges being recessed on their faces to receive flat jointing washers or discs. The ends of the superheater tubes A are provided with strong



flanges B fastened thereon, and adapted to be secured to the headers E by studs and nuts. According to this invention, each of the flanges B is formed with a recess on its outer face to receive a washer D, which is interposed between the flange and the face of the header E. The shape and dimensions of the recess are such that when the washer D is pushed home as far as it will go its aperture is concentric with the tube, and the mouth of the superheater tube has thus a full thoroughfare leading to the interior of the header. (*Accepted August* 1, 1917.)